第9卷 第2期 西北地震学报 Vol.9, No.2
1987年6月 NORTHWESTERN SEISMOLOGICAL JOURNAL June, 1987

MULTIPLE STICK-SLIP FRACTURING AND PALEOSEISMIC RECURRENCE PERIOD ON THE ERTAI ACTIVE FAULT

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Abstract

Based on correlation of horizontal dislocation with the length of betrunked gulch, it is proposed that the active Ertai Fault had ruptured 5 times since Holocene. The earthquake of M= 8 took place during every stick-slip fracturing. Paleoseismic recurrence period was approximately 1800 yrs.We have estimated that the Ertai Fault will rupture again in the 3700 A.D.The earthquake will occur on the southern end of the active fault. This estimation is suppored by severed evidences, such as the surface of multi-seismic fault, multible cliff of displacement, seismic colluvial deposits and excavation.

The active Ertai Fault was the seismogenetic tectonics of the 1931 Fuyun Earthquake of M=8. Along the fault a long seismic fracture zone was formed during the earthquake(Seismological Bureau of Xinjiang Uygur Autonomous Region, 1985). This was a marifestation of stick-slip fracturing, when Ertai Fault recently ruptured in multi- points.From epicentral area, Kalaqinggir, to south and north, the distribution of dextral offset has some regularity (Shi Jianbang et al., 1984).In a general way, horizontal displacement is 5-8 m., the largest offset amounted to 14 m.(Fig.1).

Magnificent offset drainage systems are the indication of multible stick-slip fracturing since the fault was formed (Ding Guoyu, 1982). According to the field measurement, the interpretation of the aerophoto and the inspection in situ, we had already collected 70 data about the offset of active Ertai Fault. Next, we are going to discuss the concerning problems.

1.The length of betrunked gulch measured from large scaled aerophoto is precise to 10m. But for unity with data of small scaled aerophoto, we use the accuracy of 100m. The offsets correlate mutually to the length of

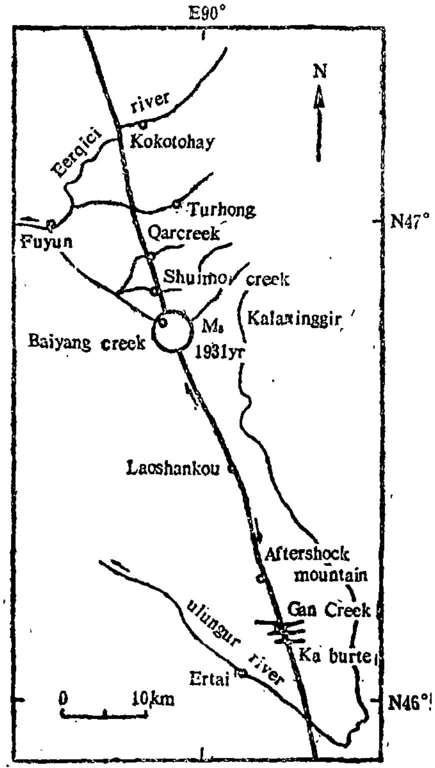

Fig. 1 Offset drainage systems along the active Ertai Fault

betrunked gulch. The correlation coefficient is 0.72, and mutual function is both their lognormal values. Their relation formula:

$$Lg\ D = 1.8 + 0.7 Lg L$$

where D is the displacement of the offset drainage systems in m., L is the length of betrunked gulch in km. This relation shows that the devolopment of betrunked gulch is closely linked with stick-slip fracturing of Ertai Fault, active Arjin Fault as well (Bo Meixiang et al., 1987).

2. We had discovered in the field that the seismic fault formed by the M= 8 earthquake in 1931 is cut by newly formed gulch due to erosion and disintegration for 53 yrs. For example, in Turhong, the new gulch was approximately 1.6 m in length, 35 cm in width, 50 cm im depth. The gulch had dissected Upper Pleistocene loamy sand breccia layer which was divided into two sections: the upper part is loamy sand, 0.5 m. in thickness and the lower part is breccia bed. In 1986, Mr. Feng Xianyue et al. had measurement 52 data of this phenomenon from Turhong to Laoshankou along Fuyun seismic fault

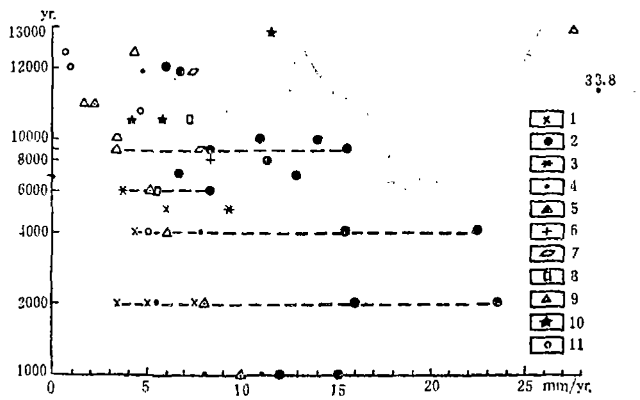

Fig. 2 Time-space distribution of dislocation rate of the offset drainage systems on the active Ertai Fault

1. Turhong 2. Qar creek 3. Shuimo creek 4. Kuoyibagaerk 5. Baiyang creek 6. Aoertahalasu 7. Laoshankou 8. Keketumusuke 9. Gan creek 10. Ertai 11. Tuntae

Table 1. The parameters of the offset drainage systems on active Ertai Fault*

Number	Location	Offset (m.)	The length of betrunked gulch(km.)	Times of the offset drainage system			Rate (mm./yr.)
				Related accumulations & C^{14} dating	Estimated from rate of retrogressive erosion(x10^4yrs.)		
1	Eerqici River	1440—3000	75.0	Q_2	87.0	Q_2^1	1.7—3.5
2	Turhong	7	0.2	Q_4	0.2	Q_4^3	3.5
3		7	0.2	Q_4	0.2	Q_4^3	3.5
4		15	0.2	Q_4	0.2	Q_4^3	7.5
5		17	0.3	4260±80yrs.	0.4	Q_4^3	4.3
6		30	0.4	Q_4	0.5	Q_4^2	6.0
7		15	0.2	Q_4	0.2	Q_4^3	7.5
8		10	0.2	Q_4	0.2	Q_4^3	5.0
9	Qar Creek	1100	15.0	Q_3	17.4	Q_2^2	6.3
10		32	0.2	Q_4	0.2	Q_4^3	16.0
11		90	0.7	Q_4	0.8	Q_4^2	11.3
12		90	0.6	Q_4	0.7	Q_4^2	12.9
13		90	0.3	Q_4	0.4	Q_4^3	22.5
14		75	0.8	Q_4	0.9	Q_4^1	8.3
15		120	1.7	Q_3	2.0	Q_3^2	6.0
16	Qar Creek	12	0.1	Q_4	0.1	Q_4^3	12.0
17		130	1.6	Q_3	1.9	Q_3^2	6.8
18		15	0.1	Q_4	0.1	Q_4^3	15.0
19		50	0.5	5735±35yrs.	0.6	Q_4^2	8.3
20		110	0.9	Q_4	1.0	Q_4^1	11.0
21		140	0.8	Q_4	0.9	Q_4^1	15.6
22		140	0.9	Q_4	1.0	Q_4^1	14.0
23		47	0.2	Q_4	0.2	Q_4^3	23.5
24		62	0.3	Q_4	0.4	Q_4^3	15.5
25		185	1.4	Q_3	1.6	Q_3^2	11.6
26		47	0.6	Q_4	0.7	Q_4^2	6.7

续表 1

Number	Location	Offset (m.)	The length of betrunked gulch (km.)	Times of the offset drainage system			Rate (mm./yr.)
				Related accumulations & C^{14} dating	Estimated from rate of retrogressive erosion ($x10^4$yrs.)		
27	Shuimo Creek	1000	30.0	Q_3	34.8	Q_2^2	2.9
28		22	0.5	6285±85yrs	0.6	Q_4^2	3.7
29		47	0.4	4885±115yrs.	0.5	Q_4^2	9.4
30	Kuoyibagaer	540	1.4	Q_3	1.6	Q_3^2	33.8
31		31	0.3	Q_4	0.4	Q_4^3	7.8
32		11	0.2	Q_4	0.2	Q_4^3	5.5
33		8	0.1	Q_4	0.1	Q_4^3	8.0
34		11	0.1	Q_4	0.1	Q_4^3	11.0
35		11	0.2	Q_4	0.2	Q_4^3	5.5
36	Kuoyibagaer	93	1.6	Q_3	1.9	Q_3^2	4.9
37	Baiyang Creek	2000	5.5	Q_3	6.4	Q_3^1	31.3
38		31	1.2	Q_3	1.4	Q_3^2	2.2
39		31	0.8	Q_4	0.9	Q_4^1	3.4
40		16	0.2	Q_4	0.2	Q_4^3	8.0
41		31	0.5	Q_4	0.6	Q_4^2	5.2
42		16	0.2	Q_4	0.2	Q_4^3	8.0
43		10	0.1	Q_4	0.1	Q_4^3	10.0
44	Aoertahalasu	67	0.7	Q_4	0.8	Q_4^2	8.4
45	Laoshankou	140	1.6	Q_3	1.9	Q_3^2	7.4
46		70	0.8	6340±210yrs.	0.9	Q_4^1	7.8
47	West of the Sangrao	34	0.9	Q_4	1.0	Q_4^1	3.4
48	Keketumusuke	88	1.0	Q_4	1.2	Q_4^1	7.3
49		33	0.5	Q_4	0.6	Q_4^2	5.5
50	Aftershock Mountain	67	5.4	Q_3	6.3	Q_3^1	1.1
51		67	0.7	Q_4	0.8	Q_4^2	8.4

续表 1

Number	Location	Offset (m.)	The length of betrunked gulch(km.)	Times of the offset drainage system: Related accumulations & C^{14} dating	Estimated from rate of retrogressive erosion($\times 10^4$yrs.)		Rate (mm./yr.)
52	North of the Gan Creek	123	1.1	Q_3	1.3	Q_3^2	1.8
53		100	2.0	Q_3	2.3	Q_3^2	4.4
54	Gan Creek	800	2.5	Q_3	2.9	Q_3^2	27.6
55		24	0.3	Q_4	0.4	Q_4^3	6.0
56		95	6.0	Q_3	7.0	Q_3^1	1.4
57	Utibulak	450	6.0	Q_3	7.0	Q_3^1	6.4
58		80	2.9	Q_3	3.4	Q_3^2	2.4
59	Karburte	450	4.5	Q_3	5.2	Q_3^2	8.6
60		30	3.7	Q_3	4.3	Q_3^2	0.7
61		67	5.0	Q_3	5.8	Q_3^1	1.2
62	Northeast of the Ertai	42	4.9	Q_3	5.7	Q_3^1	0.7
63		30	2.4	Q_3	2.8	Q_3^2	10.7
64		48	3.7	Q_3	4.3	Q_3^2	1.2
65		67	5.0	Q_3	5.8	Q_3^1	1.2
66	Tuntae	61	4.0	Q_3	4.6	Q_3^2	1.3
67		16	2.0	Q_3	2.3	Q_3^2	0.7
68		18	1.7	Q_3	2.0	Q_3^2	0.9
69		20	0.3	Q_4	0.4	Q_4^3	5.0
70	Ulungur River	1300	190.0	Q_1	220.4	Q_1^1	0.6

*Fractional data were provided by Hu Fangqiu, Liu Jingyuan and Ge Shumo

Table 2. The history of stick-slip fracturing of Ertai active fault

Number	Time to present (yrs.)	Slip rate(mm./yr.)		Fracturing member	Fracturing direction
		Interval	Average		
5	1000	8.0—15.0	11.2	Qar--Baiyang Creek	from N to S
4	2000	3.5—23.5	9.9	Turhong--Baiyang Creek	from Qar Creek to S & N
8	4000	4.3—22.5	10.2	Turhong--Ertai	from Qar Creek to S & N
2	6000	3.7—8.3	5.7	Qar Creek--Keketumusuke	from N to S
1	9000	3.4—15.6	8.8	Qar Creek--Laoshankou	from N to S

zone. Based on these data, it can be deduced that the retrogressive erosion rate of the gulch is nearly 86.2mm/yr. in the Fuyun region. It is the same as Haiyuan area (Cheng Shaoping et al, 1984).

On the basis of today's rate of retrogressive erosion, the formation time of betrunked gulch can be roughly estimated. The result is the same as the estimation obtained from the age of the related accumulation within betrunked gulch (Table 1).

3. When plotting the data of Table 1 (Fig. 2), we shall discover:

(1) The formation of betrunked gulch posses clear periodicity. Since Holocene, the phenomena of betrunked gulch have been appeared every 1000-2000 yrs., following the stick-slip fracturing of the active Ertai Fault. This periodical stick-slip fracturing is the cause of recurrence of paleo-earthquakes (Table 2).

(2) By studying on the offset drainage system we know that at least 5 paleoearthquakes took place along active Ertai Fault since Holocene. These earthquakes had occurred at intervals of 1000, 1000, 2000, 2000 and 3000 yrs., respectively. These earthquakes were verified by the excavation (Ge Shumo et al., 1986).

(3) Based on the calculation, the average rate of stick-slip fracturing of the active fault was approximately 7.7 mm./yr. since Latepleistocene, Q_4^1--8.1, Q_4^2--7.5, Q_4^3--10.4 mm./yr. Total average of slip rate is 7.9 mm./yr.

4. Preceding conclusions have ample geological evidences. Especially, the active Ertai Fault had ruptured many times, and it produced a series of paleoseismic traces (Feng Xianyue et al., 1982), such as the surface of multi-seismic fault, multiple fault scarp, multi-seismic collapse, and throwing phenomena, which can be found everywhere on the active Ertai Fault.

In 1984, taking part in the work were those: Ge Shumo, Guo Hengzu, Xiang Zhiyong, Liu Jingyuan, Pan Jinwen, Xu Daozun, Wang Weibing, Ma Jin, Zhu Haizhi, Zhang Yuming, Geng Naiguang, Yao Xiaoxing, Du Yijun, Ma Shengli et al. At last, we express our thanks to Mr. Ge Shumo, Xi Yi, Liang Kuangyi and Mr. He Yongnian for their helps.

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二台活断层的多次粘滑破裂和古地震复现期

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摘　　要

研究二台活断层的水平断距与断尾沟长度的关系发现，该断层自全新世以来至少破裂过5次。每次粘滑破裂一般都发生8级地震，其古地震复现期平均为1800年左右。预计公元3700年二台断层将再次破裂发震，地点在活断层的南端。这种估计已为多级地震断层、多级断崖、多个地震崩积楔及开挖工作证实。