[Tectonics]

Supporting Information for

Direct evidence for dextral shearing in the Shanxi Graben System: geologic and geomorphologic constraints from the North Liulengshan Fault

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Introduction

This Supporting Information includes the lab procedures of OSL dating, field-measured fault slip data, and summary of geological and geomorphological evidence of dextral strike-slip in Shanxi Graben System..

Text S1 OSL dating lab procedures

Sample preparation was carried out in the laboratories of the Key Laboratory of Crustal Dynamics of the National Institute of Natural Hazards. Samples were processed under subdued red light in the laboratory (LED array light source with a central wavelength of 661 nm). To ensure maximal shielding, the outer ~5 cm of the sample was removed from each end of the stainless tubes and used for radioisotope (U, Th, K) concentration analysis and determining the water content, and only the sediments in the center of the stainless tubes were used for equivalent dose measurement. In this study, we used quartz material for OSL dating. For each OSL sample, the coarse-grained (90-125μm) quartz fraction was isolated for equivalent dose measurements. Bulk materials were first wet-sieved to obtain the coarse-grained fractions, followed by treatment with 30% hydrogen peroxide and 30% hydrochloric acid (HCl) to remove organic matter and carbonates, respectively. Finally, these prepared fractions were etched with 40% hydrofluoric acid for one hour (followed by a 10% HCl rinse) to remove the outer alpha-irradiated surface of the quartz grains and to eliminate any potential feldspar contamination. Magnetic separation was used to remove heavy minerals. The quartz grains were then mounted as monolayers onto 9.8-mm-diameter steel discs using silicone oil adhesive (sample diameter, 2 mm).

Luminescence measurements were made on a Risøe TL/OSL DA-20-C/D reader. Laboratory irradiation used a 90Sr/90Y beta source with a dose rate of 0.09 Gy/s. Detection was through 3.0 mm Hoya U-340 filter in front of the 9523QB15 photomultiplier. The blue light emitting diodes (λ = 470 ± 20 nm, excitation temperature =125 °C) and infrared (λ = 830 nm) LED units were used for stimulation. To test the purity of the quartz extracts, OSL IR depletion ratio was employed to check feldspar contamination in the measured quartz. Equivalent doses of quartz were determined by using the Single-aliquot Regenerative-dose protocol (SAR) procedure (Murry & Wintle, 2000, 2003). Signals of initial 0.8 s (the first 5 channel integration values) of stimulation were integrated for growth curve construction after subtracting background (the last 6-10 channel integration values). The following table shows the SAR procedure used for equivalent dose determination in this study.

Step	Treatment
1	Dose (natural or laboratory)
2	Preheat for 10 seconds at 260°C
3	Stimulate for 40 seconds at 125°C
4	Test dose
5	Preheat for 10 seconds at 220°C
6	Stimulate for 40 seconds at 125°C
7	Stimulate for 40 seconds at 280°C
8	Return to Step 1

The NexION300D ELEMENT Plasma Mass Spectrometer was used to determine the contents of U, Th, and the Z-2000 polarized Zeeman graphite furnace atomic absorption spectrometry was used to determine the content of K. The cosmic ray dose rate was estimated according to Prescott & Hutton (1994). Alpha value for coarse quartz grains was not considered, whereas beta value was timed by 0.9 (Rees-Jones, 1995). The environmental dose rate was determined based on the conversion relation between dose rate of quartz and the contents of U, Th, and K (Aitken, 1998). The environmental dose rates were also corrected using the instu-measured water content in the samples. Finally, OSL dates for each sample were calculated from the acquired equivalent dose and environmental dose rate.

References:

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Table S1 Field-measured fault slip data

	Number	Rake	Ratio of dip-slip to strike-slip	Fault strike*/ dip angle
Site 2	1	-131°	1.2:1	190°/65°
	2	-140°	0.8:1	
	3	-145°	0.7:1	
	4	-126°	1.4:1	
	5	-120°	1.7:1	
	6	-134°	1.0:1	
	7	-117°	2.0:1	
	8	-115°	2.1:1	
	9	-112°	2.2:1	
	10	-116°	2.1:1	
	11	-119°	1.8:1	189°/67°
Site 1	1	-123°	1.5:1	217°/58°
	2	-127°	1.3:1	
	3	-120°	1.7:1	

* Note that the fault strikes are actually calculated from the fault dips measured in the field. They are perpendicular to each other (with a difference of 90°).

Table S2 Geological and geomorphological evidence of dextral strike-slip of the Shanxi Graben System in the published literature

Fault	Fault Strike	Landform	Descriptions	Dextral slip rate (mm/a)	Reference
Kouquan Fault	NNE	Offset rivers	Rivers were right-laterally displaced with offsets of 200-400 m	1.8-3.6	Ding & Lu, 1983
		Offset rivers	The Shili River near Datong turns to the south after exiting the mountain pass, indicating that the fault has a certain horizontal displacement		Wang et al., 1996
North Liulengshan Fault (West segment)	NNE	Offset gullies	The fault has a controlling effect on the Holocene landform and drainage system. The faulted drainage system can be divided into three levels. The first-order dextral dislocations can reach 125-145 m, and the smallest group of gullies has a dextral dislocation of 15 -27 m		Deng & Xu, 1995
		Offset gullies	A serious gullies have been dextrally offset and their right-lateral displacements range from 15.4 to 145 m between Beimazhuang and Shuimenkou Villages	1.26	Xu et al., 1996
		Offset gullies	Consistently dextral deflection of stream channels of different sizes when crossing the fault，and the amount of dislocation is mostly between several meters to tens of meters．	1. 6±0. 3	Luo et al., 2022
Xizhoushan Fault (West segment)	NNE	Offset ridges and gullies	To the east of Shilingguan village, the fault causes more than ten gullies to undergo regular dextral displacement, and the gully terraces were deformed. The loess beams between the twisted gullies shifted to the north in unison, making the bedrock beams on the east side of the fault form a crescent-shaped section.	5.68	Xu et al., 1986
		Offset gullies	Modern alluvial terraces of gullies and loess accumulations are systematically deflected, indicating that the fault is characterized by normal dextral strike-slip movements	2.0±0. 2	Yu et al., 2020
		Offset gullies	The fault affects late Quaternary landscapes and display a right-lateral offset of stream channels and gullies with a minor downthrow component. The offsets measured from SPOT images group around three values.		Zhang et al., 1998
Huoshan Fault	NNE	Offset gullies	The strong dextral strike-slip activity along the Huoshan fault has left obvious traces on the geomorphology. The gullies on the fault zone are uniformly dextrally dislocated, and the terraces developed in the reconstruction are deformed or displaced, and the gaps between the gullies are deformed. The mountain beam also twisted accordingly.	5.7-7.5	Xu &Deng, 1990
		Offset gullies	Along the southern fault segment, a drainage network deeply incising the early to late Pleistocene deposits is offset right-laterally across a sharp, N-S-striking fault. Two main groups of channel offsets are obtained, One, about 150±40 m and the other about 600±40 m.		Zhang et al., 1998
		Sedimentological evidence	The Huoshan fault slipped about 10-12.5 km right laterally after the Pliocene gravels were deposited.	3.5-4	Li et al., 1998; Hu et al., 2010