Supporting Information for

Rapid bedrock canyon incision during a mid-Holocene pluvial period, Qilian Shan, China

Yiran Wang[1], Michael E. Oskin[1], Youli Li[2], Huiping Zhang[3]

[1] Department of Earth and Planetary Sciences, University of California, Davis, California, USA
[2] College of Urban and Environmental Sciences, Peking University, Beijing, China
[3] Institute of Geology, China Earthquake Administration, Beijing, China

Corresponding author: Yiran Wang (yrwwang@ucdavis.edu)

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Additional Supporting Information (Files uploaded separately)

Captions for Tables S1, S2

Introduction

1. Field Survey

The Beida River terraces and riverbed were surveyed during the year 2016 and 2017. The elevation and coordinates of all the points were determined using laser range finder (~0.3m distance accuracy, 0.25° inclination accuracy) and differential GPS. For terrace survey points (Figure 2a), we specifically surveyed the terrace tread where gravel in contact with loess or alluvial deposits, and the terrace strath where gravel in contact with bedrock. The longitudinal profiles (**Figure 3a, Table S1**) are generated later by projecting survey points to the river channel.

2. Geochronology

OSL sample was collected in the field by hammering stainless steel tubes into cleaned excavation walls. Sample data and age results were provided by State Key Laboratory of Earthquake Dynamics, China Earthquake Administration. The equivalent doses (De) for the pure fine-grained quartz were determined by following the simplified multiple aliquot regenerative-dose (SMAR) protocol. **Figure S1** and **Table S3** show the growth curve of the OSL sample we present in Table 2 of the main manuscript.

10 14C samples were collected from 3 sample sites (Figure 2), on terrace treads of T1 inset terraces. All of the samples are composite of charco fragments that buried within sand and silty sand layers on top of the gravels (**Figure S2**).

3. Channel width measurements

We measure present channel widths from Google Earth imagery. We define the channel width here as the width of the water surface during the summer wet season. The Google Earth images we analyzed were generally acquired during July through September between 2010 to 2016, only a few measurements were based imagery acquired in May. Measurements were taken along the river at 100 m intervals, except for the ~1.5 km reach that around the dam (Figure 3c). The survey points are listed in **Table S2**

4. Terrace strath and bedrock exposure

The terrace treads and the paleo channel are relatively well preserved inside the mountains due to meandering of the river. **Figure S3** shows field photos of the reaches with well-preserved paleochannels and their location relative to present river channel. The locations of each photo are also annotated on Figure 4.

5. Knickzones of neighboring major rivers

In order to know whether the Beida River knickzone is the result of an isolated event that only affected one drainage area, or a regional event, we extract longitudinal profiles from neighboring rivers that both occupying large drainage area and incised deeply into the alluvial fans. The profiles are extracted from an 8 m resolution digital elevation model, produced by the Polar Geospatial Center (Shean, 2017). Both Maying River and Hongshuiba River have a major steep knickzone ~10-15 km upstream of the mountain front, similar to the Beida River (**Figure S4**).

Figure S1. Multiple aliquot regenerative-dose growth curve (SMAR) of sample BD-O-12. Detailed data in **Table S3**

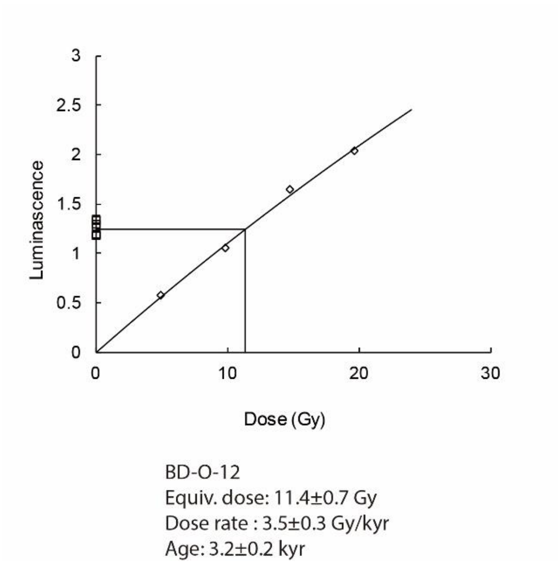

Figure S2a Photos of sample site c

Figure S2b Photos of sample site d

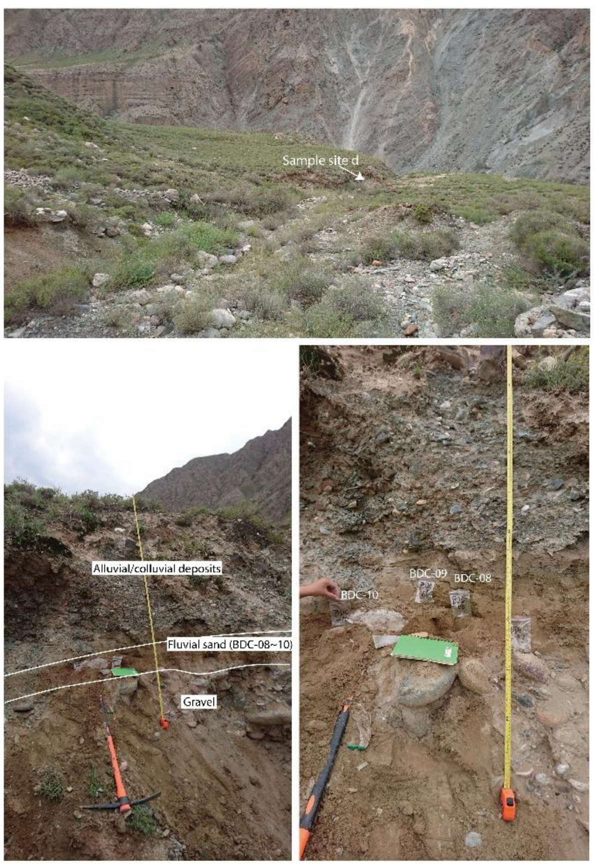

Figure S2c Photos of sample site e

Figure S3 Field photos of well-preserved terrace treads and buried paleocanyons.

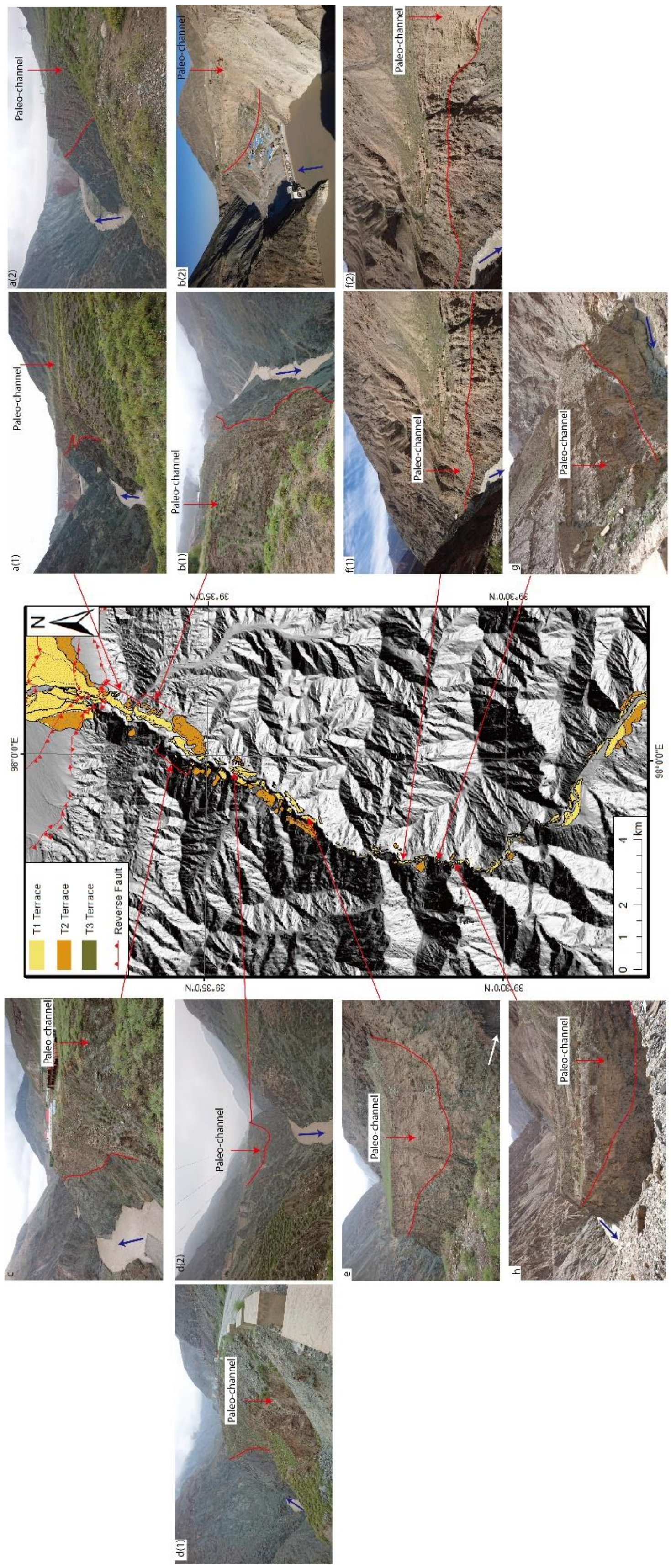
Paleo-channel
T1 Terrace
T2 Terrace
T3 Terrace
Reverse Fault
km
N
98°0'0"E
39°35'0"N
39°30'0"N

Figure S4 Longitudinal profiles of Maying River and Hongshuiba River.

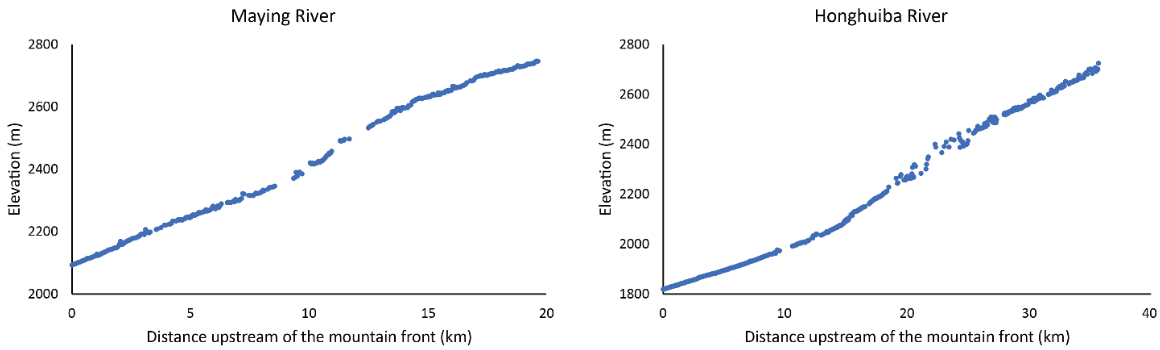

Table S1. Coordinates and elevation data for riverbed and terrace survey points (Files uploaded separately).

Table S2. Channel width measurements along the Beida River (Files uploaded separately).

Table S3. Data for sensitivity-corrected multiple aliquot regenerative-dose growth curve (SMAR) of sample BD-O-12

Sample ID	Dose (Gy)	Regenerative Luminescence Signal (Lx/Tx)	Natural Luminescence Signal (Lx/Tx)
BD-O-12	4.92	0.57	1.27
	9.83	1.05	1.33
	14.75	1.64	1.19
	19.67	2.04	1.18
	0.00	0.00	1.35
			1.19
			1.29
			1.18

Table S4. Variables used to calculate stage 2 duration and incision rate

Variable	*Value/ equations*	*Explanation*
z_{b1}	50-53 m	Apparent base level of patch 1 with respect to present river outlet.
z_{b2}	-172- -117 m	Apparent base level of patch 2 with respect to present river outlet.
I_1	3.47~7.79 m/kyr	Incision rate at outlet during formation of patch 1.
I_3	10.15-12.97 m/kyr	Incision rate at outlet during formation of patch 3.
t_3	> 3000 yr, < 4815 yr	Duration of patch 3 formation.
$T_{9.5}$	9332-9657 yr	Age of the T1' terrace near the mountain front
$T_{6.9}$	6797-6934 yr	Age of the inset T1 terrace above patch 1
$H_{9.5}$	97-107 m	The amount of incision at mountain front during $T_{9.5}$
$H_{6.9}$	32-42 m	The amount of incision along patch 1 during $T_{6.9}$

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