

**Cumulative and coseismic (during the 2016  $M_w$  6.6 Aketao earthquake) deformation of the dextral-slip Muji Fault, northeastern Pamir orogen**

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**Contents of this file**

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**Additional Supporting Information (Files uploaded separately)**

Dataset 1: submitted as a zip file

**Introduction**

This data set contains Text S1 and Figures S1-S2, which describe details of field sampling, laboratory preparation and measurement, and age calculation of terrestrial cosmogenic nuclide (TCN) <sup>10</sup>Be samples collected from fluvial terraces at Akesayi site. ESRI shape files for the mapped surface of the Muji Fault are uploaded separately in Dataset 1 in a zip file.

## **Text S1. TCN $^{10}\text{Be}$ Dating: Sampling, Preparation, Measurement, and Age Calculation**

### **1.1. Field Sampling**

Exposure ages of terraces T3 and T2d are dated using TCN  $^{10}\text{Be}$  depth profile methods. On each terrace, we dug back >1 m and dug down ~2 m along the terrace edge to expose fresh fluvial deposits. Quartz and granite gravels with diameters of 1-4 cm (>30 clasts per depth) were collected and amalgamated from six layers with regular depth intervals (generally ~40 cm) (Table 1). For the terrace T2d, one pebble sample (>30 clasts) from the terrace surface was collected to date its age. The angle from the sample site to the top of surrounding mountain ridges was measured for the topographic shielding correction.

### **1.2. Laboratory Preparation and Measurement**

Samples were prepared in the Cosmogenic Radionuclide Target Preparation Lab at University of Cincinnati (MJ1 and MJ2) and the Institute of Crustal Dynamics, China Earthquake Administration (MJ3). All rock samples were crushed, sieved and magnetically separated to obtain the nonmagnetic fraction of 250-500  $\mu\text{m}$  size. This fraction was chemically leached using a minimum of six acid leaches: one 20% HCl leach for ~12 hours; four 5% HF/HNO<sub>3</sub> leaches for ~12 hours; and one or more 1% HF/HNO<sub>3</sub> leaches for ~12 hours. A heavy liquid (lithium heteropolytungstate or sodium polytungstate) separation was used after the first 5% HF/HNO<sub>3</sub> leach. The purity of the quartz was tested using infrared stimulated luminescence in a Riso OSL Reader. The purified quartz was spiked with 0.2-0.5 mg ultrapure  $^9\text{Be}$  carrier, subsequently was dissolved in concentrated HF and then fumed three times with HClO<sub>4</sub>. The sample was then passed through anion and cation exchange columns to remove iron, aluminum, and other elements. NH<sub>3</sub>·H<sub>2</sub>O was added to the Be fractions to precipitate Be(OH)<sub>2</sub> gel. Be(OH)<sub>2</sub> was calcined at 920°C for 10 minutes in muffle furnace. The resultant BeO was mixed with Nb powder and loaded in steel targets for the measurement of the  $^{10}\text{Be}/^9\text{Be}$  ratios by accelerator mass spectrometry at PRIME Laboratory in Purdue University.  $^{10}\text{Be}/^9\text{Be}$  ratios were corrected using  $^{10}\text{Be}$  laboratory blanks (Table 1).

### **1.3. Age Calculation**

The age and  $^{10}\text{Be}$  inheritance of each depth profile (MJ1 and MJ2) were calculated in the Monte Carlo simulator (Figures S1-S2 & 5; Hidy et al., 2010). We used a  $^{10}\text{Be}$  half-life of

1.387×10<sup>6</sup> years (Korschinek et al., 2010), a scaled production rate to our sample site using the scaling scheme of Lal (1991) and Stone (2000) and a reference production rate of 4.01±0.39 atoms/g/a (Sea Level High Latitude; Borchers et al., 2016), a density varying between 1.8 and 2.5 g/cm, and an attenuation length of 160 g/cm<sup>2</sup> (Gosse and Phillips, 2001). A maximum surface-erosion depth of 10 cm and a maximum erosion rate of 2 cm/ka of the terrace surface were assigned, given that the terrace surface was quite young (<10 ka) and field observations suggested little erosion at the profile site. The age and inheritance are presented at the 95%-confidence level (Figure 5; Table 1).

For the surface sample MJ3, the age was calculated in the CRONUS-Earth online age calculator version-3.0 (Balco et al., 2008; <http://hess.ess.washington.edu/math/>), using the time-dependent scaling model ("Lm"; Lal, 1991; Stone, 2000), a density of 2.0 g/cm<sup>3</sup>, and an erosion rate of 0-2 cm/ka, and was corrected by the average <sup>10</sup>Be inheritance of depth profiles MJ1 and MJ2 (Table 1).

## References

- Balco, G., Stone, J.O., Lifton, N.A., Dunai, T.J., 2008. A complete and easily accessible means of calculating surface exposure ages or erosion rates from <sup>10</sup>Be and <sup>26</sup>Al measurements. *Quat. Geochronol.* 3, 174-195. <http://doi:10.1016/j.quageo.2007.12.001>.
- Borchers, B., Marrero, S., Balco, G., Caffee, M., Goehring, B., Lifton, N., Nishiizumi, K., Phillips, F., Schaefer, J., Stone, J., 2016. Geological calibration of spallation production rates in the CRONUS-Earth project. *Quat. Geochronol.* 31, 188-198. <http://doi.org/10.1016/j.quageo.2015.01.009>.
- Gosse, J.C., Phillips, F.M., 2001. Terrestrial in situ cosmogenic nuclides: theory and application. *Quat. Sci. Rev.* 20, 1475-1560.
- Hidy, A.J., Gosse, J.C., Pederson, J.L., Mattern, J.P., Finkel, R.C., 2010. A geologically constrained Monte Carlo approach to modeling exposure ages from profiles of cosmogenic nuclides: an example from Lees Ferry, Arizona. *Geochem. Geophys. Geosyst.* 11, Q0AA10. <http://dx.doi.org/10.1029/2010GC003084>.
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- Lal, D., 1991. Cosmic ray labeling of erosion surfaces: in situ nuclide production rates and erosion models. *Earth Planet Sci. Lett.* 104, 424-439.
- Stone, J.O., 2000. Air pressure and cosmogenic isotope production. *J. Geophys. Res.* 105 (B10), 23753-23823. <http://10.1029/2000JB900181>.

be\_gui

site specific information

latitude (deg) xx.xxx: 39.23112

longitude (deg) xxx.xxx: 74.25294

altitude (m): 4295

strike (deg): 0.0

dip (deg): 0.0

topographic/geometric shielding

read shielding data from file: shielding\_LF.txt

define factor (unitless): 1

calculate shielding

shielding value: 1.000

cover (e.g. snow, loess etc.): 1

isotope: 10Be (1.387 Ma)

% error in half-life: 5

spallogenic production (atoms/g/a)

scaling scheme: Stone 2000 after Lal 1991

reference production rate: 4.01

calculate production

site production rate: 69.81457 (paste value)

treatment of uncertainty: constant value

constant value: 69.81457

profile data import from file: \\matlab\P09C-06\_litao\P09C-06.txt

muonic production (atoms/g/a)

depth of muon fit (m): 5

calculate production

pathway	surface production	mean rel error in fit
fast muons	0.198	0.111%
neg muons	0.449	1.275%
total	0.647	

% error in total production rate: 0.0

density data

import densities from file: shielding\_LF.txt

density does not vary with depth: stochastic uniform distribut...

minimum value	maximum value
1.8	2.5

Monte Carlo parameters

sigma confidence level: 2

# profiles: 10000

Monte Carlo simulator

age (a): stochastic uniform error

minimum value	maximum value
5000	15000

erosion rate (cm/ka): stochastic uniform error

minimum value	maximum value
0	2

total erosion threshold (cm)

minimum value	maximum value
0.0	10

inheritance (atom/g): stochastic uniform error

minimum value	maximum value
40000	90000

neutrons: stochastic normal error

mean value	std
160	5

version 1.2

create plots

run save load load from settings

Figure S1. Parameters used in Monte Carlo modeling (Hidy et al., 2010) of depth profile samples MJ1.

be\_gui

**site specific information**

latitude (deg) xxx.xxx: 39.23064

longitude (deg) xxx.xxx: 74.25609

altitude (m): 4291

strike (deg): 0.0

dip (deg): 0.0

**isotope**

10Be (1.387 Ma)

% error in half-life: 5

**muonic production (atoms/g/a)**

depth of muon fit (m): 5

calculate production

**Monte Carlo parameters**

sigma confidence level: 2

# profiles: 10000

**topographic/geometric shielding**

read shielding data from file: shielding\_LF.txt

define factor (unitless): 1

calculate shielding

shielding value: 1.000

**spallogenic production (atoms/g/a)**

scaling scheme: Stone 2000 after Lal 1991

reference production rate: 4.01

calculate production

site production rate: 69.67449 (paste value)

treatment of uncertainty: constant value

constant value: 69.67449

pathway	surface production	mean rel error in fit
fast muons	0.198	0.111%
neg muons	0.449	1.486%
total	0.647	

% error in total production rate: 0.0

**Monte Carlo simulator**

age (a): stochastic uniform error

minimum value: 1000, maximum value: 5000

erosion rate (cm/ka): stochastic uniform error

minimum value: 0, maximum value: 2

total erosion threshold (cm): 0.0, maximum value: 10

inheritance (atom/g): stochastic uniform error

minimum value: 10000, maximum value: 60000

neutrons: stochastic normal error

mean value: 160, std: 5

**density data**

import densities from file: shielding\_LF.txt

density does not vary with depth: stochastic uniform distribut...

minimum value: 1.8, maximum value: 2.5

**profile data**

import from file: Matlab\P09C-05\_litao\P09C-05.txt

create plots

run

save

load

load from settings

Figure S2. Parameters used in Monte Carlo modeling (Hidy et al., 2010) of depth profile samples MJ2.