Supplement of

Timing of exotic, far-traveled boulder emplacement and paleo-outburst flooding in the central Himalayas

Marius L. Huber et al.

Correspondence to: Marius L. Huber (marius.huber@univ-lorraine.fr)

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Supplement 1 (S1): Field survey and boulder provenance

S1.1 Overview maps of field sites

Samples on tributary fan, south of Devighat, “Trishuli downstream”
Sampled boulders: NEQ/162 44, …45, …46 and …47
Many boulders spread on a tributary fan at the Trishuli River, south of Devighat

Figure S1.1-1: Google Earth, n. d., [satellite imagery for central Nepal], Retrieved June to November 2017, Google Earth Version 7.3.0
Samples at fill terrace, Betrawati, “Trishuli upstream”
Sampled boulders: NEQ/162 60, …61, …66 and …67.

Figure S1.1-2: Google Earth, n. d., [satellite imagery for central Nepal], Retrieved June to November 2017, Google Earth © 2016 DigitalGlobe
Samples north of Betrawati “Trishuli upstream”
Sampled boulders: NEQ/162 58, and …59.

Figure S1.1-3: Google Earth, n. d., [satellite imagery for central Nepal], Retrieved June to November 2017, Google Earth © 2016 DigitalGlobe
Samples around Balephi, Sunkoshi/ Balephi Khola
Sampled boulders: NEQ/161 01, …02 and …03. And NEQ/162 79, …80 and …98.

Figure S1.1-4: Google Earth, n. d., [satellite imagery for central Nepal], Retrieved January 2020, Google Earth © 2020 CNES/Airbus
S1.2 Sampled boulders in detail

- **NEQ/162 44** ("Trishuli downstream")

**Orthogneiss** of Higher Himalayan origin.
NEQ/162 45 (‘Trishuli downstream’)

Orthogneiss of Higher Himalayan origin.
• **NEQ/162 46** (“Trishuli downstream”)

*Orthogneiss* of Higher Himalayan origin.
Phyllitic schist of Lesser Himalayan sequence, most likely Kuncha Formation within Nawakot Complex, Dandagaon Formation could also be possible.
Phyllite of Lesser Himalayan sequence, most likely Kuncha Formation within Nawakot Complex, Dandagaon Formation could also be possible.
**NEQ/162 59** ("Trishuli upstream")

*Orthogneiss* of Higher Himalayan origin.
• **NEQ/162 60** ("Trishuli upstream")

Schist of Lesser Himalayan sequence, most likely Kuncha Formation within Nawakot Complex Dandagaon Formation could also be possible.
• **NEQ/162 61 ("Trishuli upstream")**

**Schist** of Lesser Himalayan sequence, most likely Kuncha Formation within Nawakot Complex, Dandagaon Formation could also be possible.
Schist of Lesser Himalayan sequence, most likely Kuncha Formation within Nawakot Complex, Dandagaon Formation could also be possible.
Phyllitic schist of Lesser Himalayan sequence, most likely Kuncha Formation within Nawakot Complex, Dandagaon Formation could also be possible. Different fabric than 47, 58, 60, 61 and 66.
Orthogneiss of Higher Himalayan Crystallines (no Lesser Himalayan sequence), with garnets, maybe with leucosomes, migmatitic, too homogenous for a paragneiss.
whitish orthogneiss of undifferentiated Higher Himalayan Crystallines (no lesser Himalayan sequence), no garnet found.
Augengneiss, likely Uleri-gneiss of Lesser Himalayan sequence, outcrops only just below the MCT in the study region, no intrusions mapped or known to the authors which are located south of these areas (Shrestha et al., 1986; Dhital, 2015), with garnets.
Augengneiss, possibly metagranitoide, of Higher Himalayan Crystallines (no Lesser Himalayan sequence)
Augengneiss of Higher Himalayan Crystallines (no Lesser Himalayan sequence), structure quite common in the Higher Himalayan Crystallines.
Augengneiss of Higher Himalayan Crystallines (no Lesser Himalayan sequence), structure quite common in the Higher Himalayan Crystallines.
S1.3 Fill-terraces at Betrawati and further downstream

Figure S1.3-A:
Coordinates of viewpoint:
27.96925, 85.18104
Betrawati fill-terrace at river-cut seen from different angle than Figure 2B.
Deposit has sorting, some grading and clast-supported texture. Surveyed boulder NEQ/162 66 with intermediate diameter of 8.8 m sitting on top. Photo credit K. Cook, GFZ Potsdam - 2017).

Figure S1.3-B:
Coordinates of viewpoint:
27.95223, 85.16403
Large boulder (probably >10 m maximum diameter) spotted half-buried in fill-deposit approx. 3 km south of Betrawati terrace and "Trishuli upstream" boulders. Excavation of boulder after deposition by river incision likely (river behind utility pole).

Figure S1.3-C:
Coordinates of viewpoint:
27.94721, 85.16353
Boulder of B seen from other angle (in red circle). Hydropower facility in the foreground.
Supplement 2 (S2): Paleo-hydrologic discharge estimation

Topographic maps used for river channel cross-section extraction

Topo-maps by the Government of Nepal, Survey Department produced in co-operation with the Government of Finland and the Finnish Meteorological Institute.

Following map sheets are covering the study area and were utilised for channel cross-section extraction (including scale and year of publication):
- **2785 01B Nuwakot**, 1 : 25 000, 1996 (20 m contour spacing)
- **2785 01C Devighat**, 1 : 25 000, 1996 (20 m contour spacing)
- **2785 04 Barhabise**, 1 : 50 000, 1996 (40 m contour spacing)
- **2785 08 Dadapakhar**, 1 : 50 000, 1996 (40 m contour spacing)
- **2885 13 Somdan**, 1 : 50 000, 1997 (40 m contour spacing)

Cross-section site selecting was done with guidelines by Costa (1983), p.997.

Profiles were drawn with Matlab-function “manningseq” in supplementary material from Rosenwinkel et al. (2017), by Schwanghart.

Parameters, imported data and results generated with “bouldersforpaleohydrology” code-package (Matlab) accessible via URL https://gitlab.com/mlh300/bouldersforpaleohydrology/

**Basic parameters used for code** allochthonous_boulders_for_paleohydrology.m

Flood water density: \( \rho_f = 1500 \ \text{kg/m}^3 \)
Gravitational acceleration: \( g = 9.81 \ \text{m/s}^2 \)

**Basic parameters used for function** manningseq.m

Manning’s roughness coefficient for mountain streams (Chow, 1959): \( n = 0.04 \ \text{s/(m}^{4/3}) \) ("manningseq" in supplementary material from Rosenwinkel et al. (2017), by Schwanghart)
Input data for code allochthonous_boulders_for_paleohydrology.m

Table S2-1: Boulders import table:

| sample name    | intermediate diameter [m] | density of boulder rock material [kg/m^3] | topoprofiles |
|----------------|---------------------------|-------------------------------------------|--------------|
| NEQ/161 01     | 8.7                       | 2800                                      | 11,12        |
| NEQ/161 02     | 4.5                       | 2800                                      | 11,12        |
| NEQ/161 03     | 29.9                      | 2800                                      | 11,12        |
| NEQ/162 44     | 9.2                       | 2800                                      | 6,7          |
| NEQ/162 45     | 9.9                       | 2800                                      | 6,7          |
| NEQ/162 46     | 12.5                      | 2800                                      | 6,7          |
| NEQ/162 47     | 18                        | 2700                                      | 6,7          |
| NEQ/162 58     | 13.4                      | 2700                                      | 1,2          |
| NEQ/162 59     | 8.5                       | 2800                                      | 1,2          |
| NEQ/162 60     | 18.6                      | 2700                                      | 3,4          |
| NEQ/162 61     | 14.7                      | 2700                                      | 3,4          |
| NEQ/162 66     | 8.8                       | 2700                                      | 3,4          |
| NEQ/162 67     | 9.9                       | 2700                                      | 3,4          |
| NEQ/162 79     | 9.5                       | 2800                                      | 9,10         |
| NEQ/162 80     | 11.4                      | 2800                                      | 9,10         |
| NEQ/162 98     | 9.4                       | 2800                                      | 9,10         |
Table S2-2.1: Topoprofile import table (1), d and z in meter, S in rad

| topo | topo2 | topo3 | topo4 | topo5 |
|------|-------|-------|-------|-------|
| 28°02′07″N, 85°11′38.72″E | 28°00′26.87″N, 85°11′00.67″E | 27°59′12.22″N, 85°10′48.65″E | 27°58′41.48″N, 85°10′54.34″E | 27°58′12.08″N, 85°10′53.10″E |
| d | 0 | 0 | 0 | 0 |
| z | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 |
| z | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 |
| z | 0 | 0 | 0 | 0 |

Table S2-2.2: Topoprofile import table (2), d and z in meter, S in rad

| topo6 | topo7 | topo8 | topo9 | topo10 |
|-------|-------|-------|-------|-------|
| 27°51′36.29″N, 85°13′43.84″E | 27°51′24.16″N, 85°13′16.79″E | 27°51′21.20″N, 85°13′44.40″E | 27°44′41.99″N, 85°46′39.96″E | 27°44′24.34″N, 85°46′41.10″E |
| d | 0 | 0 | 0 | 0 |
| z | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 |
| z | 0 | 0 | 0 | 0 |
| d | 0 | 0 | 0 | 0 |
| z | 0 | 0 | 0 | 0 |
Table S2-2.3: Topoprofile import table (3), d and z in meter, S in rad

| topo11 | topo12 | topo13 |
|--------|--------|--------|
| 27°43'44.73"N, 85°46'45.76"E | 27°43'41.55"N, 85°46'44.38"E | 27°43'28.60"N, 85°46'41.86"E |
| d_11 | z_11 | S_11 | d_12 | z_12 | S_12 | d_13 | z_13 | S_13 |
| 48.5 | 960 | 69.5 | 960 | 213.9 | 960 |
| 90.9 | 920 | 128.3 | 920 | 534.8 | 920 |
| 171.1 | 880 | 197.9 | 880 | 625.7 | 880 |
| 240.6 | 840 | 235.3 | 840 | 673.8 | 840 |
| 294.1 | 800 | 320.9 | 800 | 850.3 | 800 |
| 342.2 | 760 | 390.4 | 760 | 898.4 | 760 |
| 395.7 | 720 | 443.9 | 720 | 935.8 | 720 |
| 449.2 | 680 | 511.4 | 680 | 1048.1 | 680 |
| 459.9 | 671 | 540.1 | 670 | 1069.5 | 667 |
| 545.5 | 671 | 609.6 | 670 | 1144.4 | 667 |
| 550.8 | 680 | 625.7 | 680 | 1155.1 | 680 |
| 582.9 | 720 | 668.4 | 720 | 1326.2 | 720 |
| 636.4 | 760 | 695.2 | 760 | 1417.1 | 760 |
| 684.5 | 800 | 741.3 | 800 | 1470.6 | 800 |
| 738 | 840 | 780.7 | 840 | 1679.1 | 840 |
| 812.8 | 880 | 850.3 | 880 | 1802.1 | 880 |
| 844.9 | 920 | 898.4 | 920 | 1844.9 | 920 |
| 903.7 | 960 | 984 | 960 | 1909.1 | 960 |
| 973.3 | 1000 | 1155.1 | 1000 | 1978.6 | 1000 |
### Table S2-3: Paleohydrology results from boulders

| Sample name | Boulder diameter [m] | Density of boulder rock material [kg/m^3] | Topoprobe sections used for calculation | Flow velocity [m/s] | Flow discharge [m^3/s] | Flow height [m] |
|-------------|----------------------|------------------------------------------|----------------------------------------|---------------------|------------------------|-----------------|
|             |                      |                                          |                                        | Coates (1983) Clarke (1996) Alexander & Cooler (2016) | Coates (1983) Clarke (1996) Alexander & Cooler (2016) | Coates (1983) Clarke (1996) Alexander & Cooler (2016) |
| NEQ/161 01 | 8.7                  | 2900                                     | 11.12                                  | 10.2                | 9.3                    | 6.0             | 1.64E+04      | 1.25E+04 | 3.39E+03 | 15.9 | 13.7 | 6.4 |
| NEQ/161 02 | 4.5                  | 2900                                     | 11.12                                  | 7.8                 | 6.7                    | 4.3             | 7.26E+03      | 4.62E+03 | 1.34E+03 | 10.0 | 7.7  | 3.7 |
| NEQ/161 03 | 29.9                 | 2900                                     | 11.12                                  | 16.7                | 17.3                   | 11.2            | 8.95E+04      | 1.03E+05 | 2.25E+04 | 40.5 | 43.6 | 19.0 |
| NEQ/162 44 | 9.2                  | 2900                                     | 6.7                                    | 10.4                | 9.6                    | 6.2             | 1.31E+05      | 1.02E+05 | 2.13E+04 | 27.2 | 24.5 | 12.6 |
| NEQ/162 45 | 9.9                  | 2900                                     | 6.7                                    | 10.7                | 10.0                   | 6.4             | 1.44E+05      | 1.15E+05 | 2.44E+04 | 28.3 | 25.7 | 13.4 |
| NEQ/162 46 | 12.5                 | 2900                                     | 6.7                                    | 11.8                | 11.2                   | 7.2             | 1.67E+05      | 1.66E+05 | 3.74E+04 | 32.2 | 30.2 | 16.1 |
| NEQ/162 47 | 18                   | 2700                                     | 6.7                                    | 13.6                | 12.9                   | 8.3             | 3.27E+05      | 2.14E+05 | 6.19E+04 | 40.1 | 37.1 | 20.0 |
| NEQ/162 58 | 13.4                 | 2700                                     | 1.2                                    | 10.1                | 10.8                   | 7.2             | 1.10E+04      | 8.19E+03 | 2.59E+03 | 6.4  | 5.4  | 2.8 |
| NEQ/162 59 | 8.5                  | 2800                                     | 1.2                                    | 10.1                | 9.0                    | 6.0             | 6.74E+03      | 4.89E+03 | 1.55E+03 | 4.9  | 4.1  | 2.1 |
| NEQ/162 60 | 18.6                 | 2700                                     | 3.4                                    | 15.8                | 12.9                   | 8.5             | 3.11E+04      | 2.47E+04 | 5.35E+03 | 16.0 | 14.3 | 9.6 |
| NEQ/162 61 | 14.7                 | 2700                                     | 3.4                                    | 12.5                | 11.5                   | 7.5             | 2.19E+04      | 1.60E+04 | 3.63E+03 | 13.5 | 11.5 | 5.4 |
| NEQ/162 66 | 8.8                  | 2700                                     | 3.4                                    | 10.2                | 8.9                    | 5.8             | 1.04E+04      | 6.43E+03 | 1.60E+03 | 9.3  | 7.2  | 3.4 |
| NEQ/162 67 | 9.9                  | 2700                                     | 3.4                                    | 10.7                | 9.4                    | 6.2             | 1.23E+04      | 7.89E+03 | 1.62E+03 | 10.1 | 8.1  | 3.8 |
| NEQ/162 79 | 9.5                  | 2800                                     | 9.10                                   | 10.5                | 9.7                    | 6.3             | 9.26E+03      | 6.92E+03 | 1.80E+03 | 12.1 | 10.4 | 4.8 |
| NEQ/162 80 | 11.4                 | 2800                                     | 9.10                                   | 11.3                | 10.6                   | 6.9             | 1.19E+04      | 9.52E+03 | 2.37E+03 | 13.9 | 12.3 | 5.6 |
| NEQ/162 98 | 9.4                  | 2800                                     | 9.10                                   | 10.5                | 9.6                    | 6.3             | 9.11E+03      | 6.86E+03 | 1.77E+03 | 12.0 | 10.3 | 4.7 |
Supplement 3 (S3): Boulder exposure ages

Surface exposure dating with cosmogenic nuclides developed substantially in the last two decades and has become a powerful tool in analysing landscape evolution in Quaternary Geology and Geomorphology (e.g. Ivy-Ochs and Kober, 2008). Taking into account local cosmogenic nuclide production and topographic shielding, which lowers production, a surface exposure age is calculated from the cosmogenic nuclide concentrations by solving for t in Equation S3-1 below, where nuclide concentration N [atoms g$^{-1}$] is given as a function of time t [a] with production rate P [atoms g$^{-1}$ a$^{-1}$] and decay constant $\lambda$ [a$^{-1}$]. Equation S3-1 simplifies the evolution of cosmogenic nuclide concentrations by neglecting inheritance and erosion. Following standard chemical separation procedures (details provided below), concentrations of cosmogenic nuclides are measured with accelerated mass spectrometry (AMS). The radionuclide $^{10}$Be ($^{16}$O(n,4p3n)$^{10}$Be) is used in this study for cosmogenic nuclide dating because the target mineral quartz (SiO$_2$) is abundant in the sampled lithologies. Exposure dating with $^{10}$Be is a well-established method, comparably easy to apply and delivers reliable results for the targeted time-frame (Dunai, 2010).

$$N(t) = \frac{P}{\lambda} \times (1 - e^{-\lambda t}) \quad (S3-1)$$

**Laboratory work**

Sample preparation was performed in the laboratories of the Geological Institute in the Earth Science Department at ETH Zurich. The procedure employed is based on Ivy-Ochs (1996) with modifications from Norton et al. (2008), which itself is adapted after Von Blanckenburg et al. (1996, 2004). Samples were crushed with high-voltage pulse power fragmentation (SELFRAg), sieved to grain sizes between 1000 μm to 250 μm and magnetically separated to remove unwanted magnetic minerals from each sample. Repetitive acid treatment with diluted hydrochloric (HCL), hexafluorosilicic (H$_2$SiF$_6$) and hydrofluoric (HF) acids was used to remove minerals, mainly oxides, carbonates and feldspars from the sample material and isolate quartz (Norton et al. 2008). In order to fully remove meteoric $^{10}$Be from the remaining crystals, the grain boundaries of the quartz were leached with HF 3 times so as to dissolve 10% of the quartz mass at each step. Approximately 200 to 250 μg $^{10}$Be carrier solution was added to a sample weight of ~50 g to enable appropriate sample size and isotope ratio for a later measurement. Beryllium was then extracted and purified using ion exchange column chromatography. The final steps before measurement, including pressing and loading of the samples into cathodes, were performed at the Ion Beam Laboratory at ETH Zurich, Hönggerberg where the samples were measured at the LIP 0.5 MV compact accelerator mass spectrometry (AMS) facility (Tandy).

Results were normalized to secondary in-house standards S2007N and S2010N with nominal values of $^{10}$Be/$^{9}$Be = 28.1 x 10$^{-12}$ and $^{10}$Be/$^{9}$Be = 3.3 x 10$^{-12}$, respectively. S2007N and S2010N have been calibrated with our new primary standard ICN 01-5-1. ICN 01-5-1 is produced by K. Nishiizumi and has a nominal $^{10}$Be/$^{9}$Be value of 2.709 x 10$^{-11}$ (Nishiizumi et al., 2007, Christl et al., 2013). Blank corrections were performed using an arithmetic mean of 14 $^{10}$Be blanks with zero outliers measured at the Tandy facility in the period of 4 months before our last measurement was conducted (20 blanks with one outlier in a period of one year before measurement for sample NEQ/162 79). AMS measurements were performed in June and September 2017 (June 2018 for sample NEQ/162 79).

**Calculation of ages**

Subsequently cosmogenic exposure ages were computed from the $^{10}$Be/$^{9}$Be ratios including analytical errors measured at the AMS facility. The “Cosmic Ray Exposure program” (CREP) code, which is accessible online via the URL http://crep.crgp.cnrs-nancy.fr (Martin et al., 2017), was used to calculate exposure ages from nuclide concentrations. This web-based computational tool was chosen because it utilizes a robust production rate calibration database set up by the Informal Cosmogenic-nuclide Exposure-age Database (ICE-D) project (http://calibration.ice-d.org). The database is continuously updated and compiles and aligns production rate calibration data published for a variety of locations globally (Martin et al., 2017). Parameters input into CREP include the $^{10}$Be concentration in the samples (calculated from the measured ratios) with 1σ-error, sample location coordinates and altitude, topographic shielding, an assumed uniform rock sample density of 2.7 g cm$^{-3}$ and the average sample thickness. We applied the Lifton-Sato-Dunai (LSD) theoretical scaling scheme (Lifton et al., 2014) for our age computation which uses analytical approximations to modelled cosmic ray particle fluxes giving specific atmospheric cross-sections for the $^{10}$Be-nuclide and the other particles involved in the corresponding nuclear reactions (Martin et al., 2017). Another input scheme is the ERA-40 atmosphere model (Uppala et al., 2005) based on a 45 year spanning database of atmospheric pressures for any locations on earth. It gives a pressure distribution approximation necessary because atmospheric
pressure has an impact on the local production rate of cosmogenic nuclides. The geomagnetic record Lifton 2016 VDM (Pavón-Carrasco et al., 2014; Laj et al., 2004; Ziegler et al., 2011) was chosen to account for variations in the earth’s magnetic field in the past. We chose a global mean production rate because no production rate calibration data was available for the whole Asian continent (see full list of references on http://crep.crg.cnrs-nancy.fr or Martin et al., 2017). We computed our ages on the 7th of June 2018.
Table S3-1: Boulder exposure ages – results

| Sample #  | River            | Lat [°] | Lon [°] | Alt. [m a.s.l.] (1) | Sample thickness [cm] | Shielding  | \(^{10}\)Be/\(^{9}\)Be ratio \([10^{-14}]\) | 1σ analytical error of ratio [%] | Sample weight [g] | Amoun of carrier (µg) (2) | \(^{10}\)Be [at/g] (3) | 1σ AMS final error [%] (4) | Exposure age ± 1σ [ka BP] (5) |
|-----------|------------------|---------|---------|---------------------|-----------------------|------------|--------------------------------|----------------------|-----------------|--------------------------|-------------------------|--------------------------|---------------------------|
| NEQ/161 01 | SUNKOSHI         | 27.729  | 85.779  | 674                 | 2.0                   | 0.86       | 3.70                           | 8.8                  | 21.381          | 201.6                    | 1.67 x 10^4            | 13.9                     | 4.98 ± 0.65               |
| NEQ/161 02 | SUNKOSHI         | 27.728  | 85.779  | 672                 | 3.0                   | 0.93       | 1.02                           | 15.3                 | 40.957          | 256.4                    | 9.18 x 10^4            | 95.8                     | maximum 0.49 (5)          |
| NEQ/161 03 | SUNKOSHI         | 27.724  | 85.778  | 686                 | 6.5                   | 0.95       | 14.83                          | 5.1                  | 34.978          | 201.9                    | 5.28 x 10^4            | 5.6                      | 13.28 ± 0.96              |
| NEQ/162 44 | TRISHULI         | 27.856  | 85.070  | 441                 | 3.0                   | 0.99       | 2.26                           | 10.5                 | 22.521          | 256.6                    | 1.10 x 10^4            | 19.1                     | 3.48 ± 0.67               |
| NEQ/162 45 | TRISHULI         | 27.856  | 85.069  | 440                 | 3.0                   | 0.99       | 6.48                           | 6.6                  | 43.087          | 201.7                    | 1.69 x 10^4            | 8.5                      | 5.22 ± 0.46               |
| NEQ/162 46 | TRISHULI         | 27.856  | 85.069  | 445                 | 3.0                   | 0.99       | 4.69                           | 7.8                  | 33.040          | 202.4                    | 1.49 x 10^4            | 11.1                     | 4.64 ± 0.54               |
| NEQ/162 47 | TRISHULI         | 27.856  | 85.068  | 445                 | 2.5                   | 0.99       | 4.81                           | 7.5                  | 41.518          | 257.1                    | 1.64 x 10^4            | 9.7                      | 5.05 ± 0.49               |
| NEQ/162 58 | TRISHULI         | 28.009  | 85.184  | 679                 | 4.5                   | 0.96       | 6.96                           | 6.8                  | 58.751          | 197.7                    | 1.32 x 10^4            | 8.5                      | 3.63 ± 0.35               |
| NEQ/162 59 | TRISHULI         | 28.009  | 85.184  | 680                 | 4.0                   | 0.95       | 2.15                           | 10.8                 | 37.292          | 200.9                    | 4.03 x 10^4            | 26.2                     | 1.06 ± 0.29               |
| NEQ/162 60 | TRISHULI         | 27.970  | 85.183  | 618                 | 2.0                   | 0.97       | 8.08                           | 5.5                  | 60.322          | 202.8                    | 1.57 x 10^4            | 6.8                      | 4.35 ± 0.37               |
| NEQ/162 61 | TRISHULI         | 27.969  | 85.182  | 609                 | 1.5                   | 0.97       | 4.26                           | 7.1                  | 40.426          | 254.7                    | 1.44 x 10^4            | 9.7                      | 4.01 ± 0.43               |
| NEQ/162 66a| TRISHULI         | 27.970  | 85.180  | 630                 | 2.0                   | 0.98       | 9.52                           | 5.7                  | 61.306          | 201.7                    | 1.85 x 10^4            | 6.7                      | 4.82 ± 0.49 (6)          |
| NEQ/162 66b| TRISHULI         | 27.970  | 85.180  | 630                 | 2.0                   | 0.98       | 4.25                           | 10.6                 | 41.450          | 304.8                    | 1.74 x 10^4            | 13.0                     |                           |
| NEQ/162 67 | TRISHULI         | 27.970  | 85.180  | 632                 | 2.5                   | 0.98       | 10.50                          | 5.3                  | 61.830          | 203.3                    | 2.06 x 10^4            | 6.1                      | 5.46 ± 0.38               |
| NEQ/162 79 | SUNKOSHI, Balephi Khola | 27.735  | 85.780  | 683                 | 1.5                   | 0.96       | 6.65                           | 14.3                 | 39.027          | 251.1                    | 2.46 x 10^4            | 16.7                     | 6.23 ± 0.92               |
| NEQ/162 80 | SUNKOSHI         | 27.734  | 85.783  | 695                 | 1.5                   | 0.95       | 11.93                          | 5.1                  | 41.942          | 255.9                    | 4.49 x 10^4            | 5.6                      | 10.96 ± 0.73              |
| NEQ/162 98 | SUNKOSHI, Balephi Khola | 27.741  | 85.777  | 693                 | 1.5                   | 0.90       | 5.05                           | 8.3                  | 40.199          | 256.3                    | 1.79 x 10^4            | 10.3                     | 4.97 ± 0.51               |

(1) elevation of sampling point
(2) 6.616 x 10^19 atoms \(^{10}\)Be per gram carrier
(3) after blank correction: 1.36 x 10^3 ± 2.44 x 10^4 \(^{10}\)Be atoms n = 14 blank measurements over 4 months in same laboratory (except for NEQ/162 79 that was corrected for a blank contribution of 1.43 x 10^3 ± 2.77 x 10^4 \(^{10}\)Be atoms, n = 20 blank measurements over 1 year in same laboratory)
(4) calculated with online version of CREp (Martin et al.2017) on 7.6.2018, see text for set parameters and production rate.
(5) not statistically different from blank, yields only a maximum concentration
(6) age was calculated using the mean \(^{10}\)Be concentrations from duplicate measurements NEQ/162 66A and NEQ/162 66B
Figure S3-1: Top: Sample numbers are added without “NEQ/162...”. Exposure ages are in ka BP. Zoom-out on tributary fan. Red line shows location of topo-profile (bottom). Bottom: boulder intermediate diameters in meters. Bing Maps. (n.d.). [Satellite Imagery for central Nepal]. Retrieved June to November 2017, from https://www.bing.com/maps, © Microsoft. Topographic profile drawn from topographic maps (see S2).
Boulders south of Devighat, Trishuli valley

Figure S3-2: Top: Sample numbers are added without “NEQ/162…”. Exposure ages are in ka BP. Middle: Zoom-out on tributary fan. Red line shows location of topo-profile (bottom). Bottom: boulder intermediate diameters in meters. Bing Maps. (n.d.). [Satellite Imagery for central Nepal], Retrieved June to November 2017, from https://www.bing.com/maps, © Microsoft. Topographic profile drawn from topographic maps (see S2).
Table S3-2: Exposure-dated moraine deposits in the central Himalayan study region – recalculated for comparison with boulder exposure ages in this study (these ages are plotted in Figure 6)

| Slope | Sample | Lat (deg) | Lon (deg) | Alt (m) | Conc | Mean | Std | Depth [cm] | Thickness [cm] | Landform allocation | Exposure age [ka] |
|-------|--------|-----------|-----------|---------|------|------|-----|-----------|--------------|-------------------|-----------------|

Note: These ages are assumed for all samples, samples were calculated with world time (UTC), moraine ages (mean weighted ages) **N.B. W.I.M. = 25 + 10 years** for all samples with CRAG and weighted calculations (see Martin et al. 2017 for details) on 1 May 2018.
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