# Supplementary Material

Figure DR1: Beryllium partition coefficients

Table DR1: Soil properties

Table DR2: Soil $^{10}$Be profiles

Table DR3: Soil $^{10}$Be inventories and fluxes

Figure DR1. Measured partition coefficients from Be sorption-desorption experiments from Boschi and Willenbring (2016), You et al. (1989), and Aldahan et al. (1999). Experimental conditions differ, leading to differences in inferred $K_{sd}$ between studies, but all show strong pH control on measured partition coefficients.

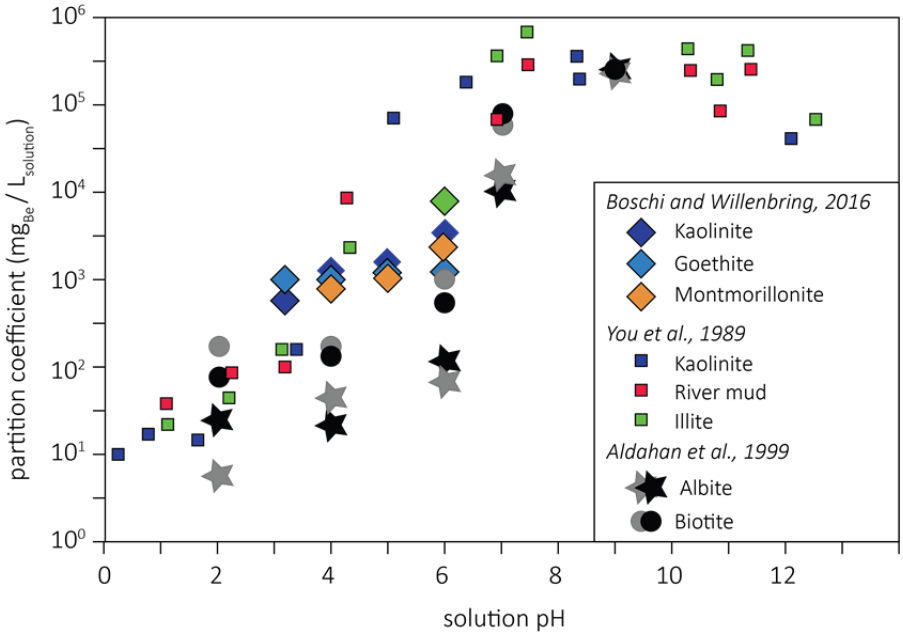

Table DR1: Soil profiles

| Site | Horizon | Depth (cm) | Rock fragments (% >2mm) | Bulk density (g $cm^{-3}$) | pH | Base Saturation |
|---|---|---|---|---|---|---|
| A | A | 0-12 | 60 | 0.80 | 7.40 | 100 |
| | Bw1 | 12-37 | 55 | 0.80 | 7.60 | 100 |
| | Bw2 | 37-69 | 70 | 0.90 | 7.70 | 99 |
| | Bw3 | 69-104 | 75 | 0.90 | 7.70 | 100 |
| B | A | 0-10 | 72 | 0.80 | 7.20 | 100 |
| | Bw | 10-37 | 65 | 0.80 | 6.70 | 77 |
| | Bw2 | 37-65 | 75 | 0.87 | 7.30 | 93 |
| | 2Cm | 65-100 | 80 | 1.56 | 8.00 | 100 |
| | R | 100-120 | 90 | 1.60 | 7.80 | 100 |
| B' | A1/A2 | 0-16 | 54 | 0.90 | 8.10 | 100 |
| | Bw1 | 16-35 | 10 | 0.90 | 7.50 | 100 |
| | Bw2 | 35-54 | 5 | 0.90 | 7.20 | 84 |
| | 2Bqk | 54-82 | 41 | 1.00 | 7.40 | 87 |
| | 2CB | 82-109 | 51 | 1.00 | 7.50 | 100 |
| | 2C1 | 109-138 | 59 | 1.20 | 8.20 | 94 |
| | 2C2 | 138-175 | 53 | 1.20 | 8.40 | 100 |
| C | A | 0-12 | 66 | 0.90 | 6.90 | 100 |
| | Bw1 | 12-22 | 45 | 0.99 | 6.80 | 87 |
| | Bw2 | 22-45 | 10 | 0.97 | 6.80 | 80 |
| | Bw3 | 45-70 | 75 | 0.80 | 7.60 | 100 |
| | Bw4 | 70-105 | 90 | 0.90 | 7.70 | 100 |
| | Bw5 | 105-132 | 90 | 1.40 | 8.00 | 100 |
| E | A | 0-13 | 65 | 0.95 | 6.90 | 96 |
| | Bt1 | 13-30 | 12 | 0.99 | 7.20 | 100 |
| | Bt2 | 30-44 | 15 | 1.03 | 7.40 | 100 |
| | Bt3 | 44-62 | 13 | 0.81 | 7.60 | 100 |
| | BC1 | 62-85 | 56 | 0.80 | 7.70 | 100 |
| | BC2 | 85-103 | 50 | 0.94 | 7.90 | 100 |
| H | Ap1 | 0-9 | 1 | 0.70 | 6.00 | 81 |
| | Ap2 | 9-21 | 1 | 0.67 | 6.60 | 89 |
| | Bw1 | 21-36 | 1 | 0.73 | 7.10 | 100 |
| | Bw2 | 36-52 | 8 | 0.75 | 7.30 | 100 |
| | Bw3 | 52-71 | 20 | 0.90 | 7.50 | 100 |
| | 2ABtb | 71-84 | 20 | 0.80 | 7.60 | 100 |
| | 2Bw1 | 84-102 | 15 | 0.81 | 7.70 | 100 |
| | 2Bw2 | 102-118 | 20 | 0.83 | 7.80 | 100 |
| | 3Bw1 | 118-140 | 25 | 0.85 | 7.80 | 100 |
| | 3Bw2 | 140-162 | 61 | 0.85 | 7.80 | 100 |
| I | Ap | 0-22 | 1 | 0.50 | 6.00 | 73 |
| | Bw1 | 22-38 | 1 | 0.45 | 6.60 | 83 |
| | Bw2 | 38-72 | 1 | 0.58 | 6.80 | 83 |
| | Bw3 | 72-85 | 1 | 0.58 | 6.90 | 79 |
| | Bwb | 85-132 | 13 | 0.62 | 7.10 | 65 |
| | 2Bwb | 132-175 | 10 | 0.76 | 7.00 | 55 |
| | 3Cr | 175-185 | 20 | 0.80 | 7.00 | 52 |

| | | | | | | |
|---|---|---|---|---|---|---|
| J | A | 0-22 | 3 | 0.48 | 6.00 | 56 |
| | Bw | 22-47 | 2 | 0.45 | 6.30 | 56 |
| | Bw2 | 47-67 | 6 | 0.58 | 6.50 | 41 |
| | Bw3 | 67-92 | 39 | 0.58 | 6.60 | 65 |
| | Bt | 92-125 | 24 | 0.62 | 6.60 | 62 |
| | BCt | 125-185 | 15 | 0.74 | 6.50 | 30 |
| M | Ag | 0-10 | 0 | 0.40 | 4.20 | 5 |
| | Bw1 | 10-28 | 0 | 0.39 | 4.70 | 3 |
| | Bw2 | 28-42 | 0 | 0.35 | 4.90 | 2 |
| | Bw3 | 42-58 | 0 | 0.37 | 5.00 | 1 |
| | Bw4 | 58-79 | 0 | 0.39 | 5.00 | 1 |
| | 2Cr | 79-101 | 0 | 0.50 | 5.10 | 2 |
| | 2AB | 101-110 | 0 | 0.50 | 5.10 | 2 |
| | 3Bwb1 | 110-120 | 0 | 0.60 | 5.20 | 1 |
| | 3Bwb2 | 120-132 | 0 | 0.70 | 5.30 | 1 |
| L | A | 0-16 | 0 | 0.31 | 3.90 | 2 |
| | AB | 16-25 | 0 | 0.43 | 4.00 | 1 |
| | Bw1 | 25-40 | 0 | 0.42 | 4.70 | 1 |
| | Bw2 | 40-56 | 0 | 0.44 | 4.80 | 1 |
| | Cr1 | 56-73 | 0 | 0.58 | 5.50 | 1 |
| | Cr2 | 73-100 | 0 | 0.62 | 5.60 | 1 |
| | Cr3 | 100-109 | 0 | 0.60 | 5.50 | 1 |
| | Cr4 | 109-118 | 0 | 0.70 | 5.30 | 2 |
| | 2Bwb | 118-130 | 0 | 0.70 | 4.90 | 2 |

Table DR2: Soil $^{10}$Be profiles

| | Sample | $^{10}$Be/$^{9}$Be * ǂ ($10^{-15}$ ratio) | Sample mass (g) | $^{9}$Be Spike (mg) | $^{10}$Be concentration * ($10^{9}$ atom g$^{-1}$) | $^{10}$Be sample inventory ** ($10^{9}$ atom cm$^{-2}$) |
|---|---|---|---|---|---|---|
| B | 0-10 | 27162 ± 298 | 0.898 | 1.001 | 2.02 ± 0.02 | 4.53 |
| | 10-37 | 25616 ± 335 | 1.001 | 1.001 | 1.71 ± 0.02 | 12.93 |
| | 37-65 | 11085 ± 199 | 1.060 | 1.001 | 0.70 ± 0.01 | 4.26 |
| | 65-100 | 3234 ± 56 | 0.836 | 1.001 | 0.26 ± 0.00 | 2.82 |
| | 100-120 | 2177 ± 39 | 1.392 | 1.001 | 0.10 ± 0.00 | 0.33 |
| B' | 0-16 | 35472 ± 1064 | 1.415 | 1.003 | 1.68 ± 0.05 | 11.12 |
| | 16-35 | 27831 ± 835 | 1.132 | 1.003 | 1.65 ± 0.05 | 25.35 |
| | 35-54 | 4205 ± 126 | 1.125 | 1.003 | 0.25 ± 0.01 | 4.07 |
| | 54-82 | 2695 ± 81 | 1.516 | 1.003 | 0.12 ± 0.00 | 1.97 |
| | 82-109 | 1383 ± 42 | 1.088 | 1.003 | 0.09 ± 0.00 | 1.13 |
| | 109-138 | 533 ± 16 | 1.169 | 1.003 | 0.03 ± 0.00 | 0.44 |
| | 138-175 | 499 ± 15 | 1.242 | 1.003 | 0.03 ± 0.00 | 0.56 |
| C | 0-12 | 18030 ± 541 | 0.778 | 1.003 | 1.55 ± 0.05 | 5.70 |
| | 12-22 | 45526 ± 1366 | 1.480 | 1.003 | 2.06 ± 0.06 | 11.22 |
| | 22-45 | 31665 ± 950 | 1.159 | 1.003 | 1.83 ± 0.05 | 36.76 |
| | 45-70 | 12306 ± 369 | 1.308 | 1.003 | 0.63 ± 0.02 | 3.15 |
| | 70-105 | 12993 ± 390 | 1.112 | 1.003 | 0.78 ± 0.02 | 2.47 |
| | 105-132 | 6719 ± 202 | 1.212 | 1.003 | 0.37 ± 0.01 | 1.40 |
| E | 0-13 | 40463 ± 470 | 1.088 | 1.001 | 2.49 ± 0.03 | 10.75 |
| | 13-30 | 51015 ± 678 | 1.248 | 1.001 | 2.73 ± 0.04 | 40.49 |
| | 30-44 | 51024 ± 642 | 1.160 | 1.001 | 2.94 ± 0.04 | 36.06 |
| | 44-62 | 25905 ± 823 | 1.320 | 1.001 | 1.31 ± 0.04 | 16.65 |
| | 62-85 | 6112 ± 90 | 0.091 | 1.001 | 4.50 ± 0.07 | 36.45 |
| | 85-103 | 1391 ± 36 | 1.112 | 1.001 | 0.08 ± 0.00 | 0.71 |
| H | 0-9 | 69777 ± 2093 | 1.219 | 1.003 | 3.84 ± 0.12 | 23.92 |
| | 9-21 | 67408 ± 2022 | 1.005 | 1.003 | 4.49 ± 0.13 | 35.77 |
| | 21-36 | 107871 ± 3236 | 1.602 | 1.003 | 4.51 ± 0.14 | 48.91 |
| | 36-52 | 84443 ± 2533 | 1.641 | 1.003 | 3.45 ± 0.10 | 38.06 |
| | 52-71 | 51322 ± 1540 | 1.538 | 1.003 | 2.24 ± 0.07 | 30.58 |
| | 71-84 | 43356 ± 1301 | 1.569 | 1.003 | 1.85 ± 0.06 | 15.40 |
| | 84-102 | 20751 ± 623 | 1.246 | 1.003 | 1.12 ± 0.03 | 13.83 |
| | 102-118 | 27976 ± 839 | 1.673 | 1.003 | 1.12 ± 0.03 | 11.90 |
| | 118-140 | 11755 ± 353 | 1.228 | 1.003 | 0.64 ± 0.02 | 8.99 |
| | 140-162 | 11067 ± 332 | 1.673 | 1.003 | 0.44 ± 0.01 | 3.23 |
| I | 0-22 | 60482 ± 1814 | 1.195 | 1.003 | 3.39 ± 0.10 | 36.93 |
| | 22-38 | 19486 ± 585 | 0.965 | 1.003 | 1.35 ± 0.04 | 9.65 |
| | 38-72 | 44595 ± 1338 | 1.022 | 1.003 | 2.92 ± 0.09 | 57.08 |
| | 72-85 | 19151 ± 575 | 0.991 | 1.003 | 1.30 ± 0.04 | 9.67 |
| | 85-132 | 53773 ± 1613 | 1.578 | 1.003 | 2.28 ± 0.07 | 57.87 |
| | 132-175 | 50301 ± 1509 | 1.091 | 1.003 | 3.09 ± 0.09 | 90.87 |
| | 175-185 | 22478 ± 674 | 1.347 | 1.003 | 1.12 ± 0.03 | 7.16 |
| J | 0-22 | 37334 ± 588 | 1.287 | 1.001 | 1.94 ± 0.03 | 19.86 |
| | 22-47 | 18084 ± 289 | 1.104 | 1.001 | 1.10 ± 0.02 | 12.07 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 47-67 | 13039 ± 280 | 1.198 | 1.001 | 0.73 ± 0.02 | 7.94 |
| | 67-92 | 9313 ± 181 | 1.055 | 1.001 | 0.59 ± 0.01 | 5.22 |
| | 92-125 | 6340 ± 145 | 1.006 | 1.001 | 0.42 ± 0.01 | 6.55 |
| | 125-185 | 5802 ± 118 | 0.881 | 1.001 | 0.44 ± 0.01 | 16.63 |
| M | 0-5 | 4337 ± 109 | 0.967 | 0.992 | 0.30 ± 0.01 | 0.59 |
| | 5-10 | 6283 ± 99 | 1.416 | 0.996 | 0.30 ± 0.00 | 0.59 |
| | 10-15 | 3367 ± 80 | 0.895 | 0.996 | 0.25 ± 0.01 | 0.98 |
| | 15-20 | 4215 ± 99 | 1.076 | 0.996 | 0.26 ± 0.01 | 0.51 |
| | 20-30 | 4763 ± 109 | 1.037 | 0.996 | 0.31 ± 0.01 | 1.10 |
| | 30-40 | 9078 ± 136 | 1.443 | 0.998 | 0.42 ± 0.01 | 1.47 |
| | 40-50 | 10769 ± 163 | 1.511 | 0.998 | 0.48 ± 0.01 | 1.71 |
| | 50-70 | 7746 ± 136 | 1.009 | 0.996 | 0.51 ± 0.01 | 3.88 |
| | 70-90 | 10037 ± 154 | 0.818 | 0.996 | 0.82 ± 0.01 | 7.27 |
| | 90-110 | 11574 ± 154 | 0.906 | 0.995 | 0.85 ± 0.01 | 8.49 |
| | 110-130 | 12831 ± 226 | 0.966 | 0.996 | 0.88 ± 0.02 | 11.49 |
| A ǂǂ | 0-12 | - | - | - | 1.41 ± 0.04 | 5.42 |
| | 12-37 | - | - | - | 1.68 ± 0.05 | 15.14 |
| | 37-69 | - | - | - | 0.89 ± 0.03 | 7.66 |
| | 69-104 | - | - | - | 1.09 ± 0.03 | 8.62 |
| L ǂǂ | 0-16 | - | - | - | 0.07 ± 0.00 | 0.36 |
| | 16-25 | - | - | - | 0.33 ± 0.01 | 1.29 |
| | 25-40 | - | - | - | 0.56 ± 0.02 | 3.53 |
| | 40-56 | - | - | - | 0.72 ± 0.02 | 5.09 |
| | 56-73 | - | - | - | 0.43 ± 0.01 | 4.28 |
| | 73-100 | - | - | - | 0.86 ± 0.03 | 14.38 |
| | 100-109 | - | - | - | 0.87 ± 0.03 | 4.69 |
| | 109-118 | - | - | - | 0.80 ± 0.02 | 5.07 |
| | 118-130 | - | - | - | 0.69 ± 0.02 | 5.77 |

* Meteoric $^{10}$Be was extracted from fine <2mm soil fractions and run for analysis at Lawrence Livermore National Lab in 1994 and 1995.

ǂ $^{10}$Be data was originally normalized to standard LLNL 10000 ($^{10}$Be/$^{9}$Be = 1.00x10$^{-11}$). Reported concentrations are recalibrated to the revised ICN standard following Nishiizumi et al. (2007) using a correction factor of 0.9042. Ratios are blank corrected by subtraction of an average processing blank of $^{10}$Be/$^{9}$Be = 3.95±2.17 10$^{-14}$.

** Per horizon inventories are calculated from fine soil (<2mm) $^{10}$Be concentrations by correcting for soil density and rock fragment abundance (Table DR1)

ǂǂ Raw data for sites A and L were not available due to incomplete record keeping since date of analysis and the inability to link to archived LLNL data. Reported $^{10}$Be concentrations for these sites are based on calculations prior to data loss, and renormalized to rICN using a correction factor of 0.9042. Omission of these sites from our analysis does not influence interpretation of nuclide inventory differences across the rainfall gradient. However, the authors are confident in the data quality of reported concentrations, as archived $^{10}$Be concentrations for 7 other profiles match unnormalized calculations based on raw data with only ~1% error.

Table DR3: Soil $^{10}$Be inventories and fluxes

| Site | Latitude (ºN) | Longitude (ºW) | Median Rainfall (mm) | $^{10}$Be inventory ($10^9$ atom/cm$^2$) | $^{10}$Be inventory (Decay corrected) * ($10^9$ atom cm$^{-2}$) | $^{10}$Be flux from dust ** ($10^3$ atom cm$^{-2}$ y$^{-1}$) | $^{10}$Be inventory from to dust inputs over 150ka ($10^9$ atom cm$^{-2}$) |
|---|---|---|---|---|---|---|---|
| A | 20.079 | 115.855 | 160 | 36.82 | 39.75 | 4.99 | 0.75 |
| B | 20.086 | 155.851 | 180 | 24.88 | 26.86 | 5.63 | 0.84 |
| B' | 20.086 | 155.851 | 180 | 44.63 | 48.18 | 5.63 | 0.84 |
| C | 20.092 | 155.845 | 210 | 60.71 | 65.53 | 6.57 | 0.99 |
| E | 20.098 | 155.805 | 570 | 141.11 | 152.32 | 16.78 | 2.52 |
| H | 20.108 | 155.782 | 1060 | 230.61 | 248.93 | 27.44 | 4.12 |
| I | 20.109 | 155.776 | 1260 | 269.24 | 290.63 | 30.72 | 4.61 |
| J | 20.108 | 155.770 | 1380 | 68.28 | 73.70 | 32.38 | 4.86 |
| M | 20.125 | 155.764 | 2500 | 38.08 | 41.10 | 37.13 | 5.57 |
| L | 20.111 | 155.751 | 3000 | 44.47 | 48.00 | 32.94 | 4.94 |

* $^{10}$Be inventories are decay corrected using the nominal age of volcanic parent material (150 ka). Due to the long half-life of $^{10}$Be, this correction does not markedly influence results and interpretation.

** $^{10}$Be fluxes in dust determined from a $^{10}$Be concentration in Asian loess of $2.8 \times 10^8$ atom g$^{-1}$ (Shen et al., 2010) and dust fluxes from Porder et al (2007) based on mean annual precipitation (P): $Q_{Dust}$ (t km$^{-2}$ y$^{-1}$) = $-2.78*10^{-4}(P^2)+1.23(P)-11.4$