Supplementary materials

**Precipitation as a key control on erosion rates in the tectonically inactive northeastern Sonoran Desert, central Arizona, USA**

**This file includes:** Supplementary Table 1, Supplementary Table 2, Supplementary Table 3

and Supplementary Fig. 1

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**Supplementary Table 1.** 1981-2010 NOAA US climate normal data (Arguez et al., 2010) for study sites.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Station** | **Name** | **Latitude** | **Longitude** | **Elevation** | **ANN-PRCP- NORMAL** | **ANN- PRCP- AVGNDS-**  **GE100HI** | **DJF- PRCP- NORMAL** | **JJA- PRCP- NORMAL** |
| USC00028112 | SOUTH PHOENIX, AZ US | 33.3814 | -112.07 | 352 | 213.87 | 16 | 73.41 | 48.26 |
| USC00029464 | WITTMANN 4 SW, AZ US | 33.7477 | -112.5983 | 509 | 270.51 |  | 95.76 | 68.33 |
| USW00093140 | PHOENIX CITY, AZ US | 33.44889 | -112.0825 | 334.7 | 207.77 | 18 | 71.12 | 52.32 |
| USC00023190 | FOUNTAIN HILLS, AZ US | 33.6027 | -111.713 | 481.6 | 295.66 | 21 | 108.71 | 63.25 |
| USW00023183 | PHOENIX AIRPORT, AZ US | 33.4277 | -112.0038 | 337.4 | 203.96 | 13 | 68.83 | 52.58 |
| USW00003184 | PHOENIX DEER VALLEY MUNICIPAL AIRPORT, AZ US | 33.68833 | -112.08167 | 443.5 | 273.3 |  | 97.79 | 65.79 |
| USC00024829 | LAVEEN 3 SSE, AZ US | 33.3371 | -112.147 | 345.9 | 215.9 | 15 | 69.85 | 59.44 |
| USC00021514 | CHANDLER HEIGHTS, AZ US | 33.20583 | -111.68194 | 434.3 | 239.52 | 21 | 86.11 | 63.75 |
| USC00020632 | BARTLETT DAM, AZ US | 33.8097 | -111.6497 | 502.9 | 376.17 | 32 | 130.81 | 88.9 |
| USC00021026 | BUCKEYE, AZ US | 33.37611 | -112.58278 | 271.3 | 222.5 | 18 | 72.14 | 69.34 |
| USC00026603 | PINNACLE PEAK, AZ US | 33.7275 | -111.8605 | 781.8 | 321.06 |  | 116.84 | 67.06 |
| USC00024977 | LITCHFIELD PARK, AZ US | 33.4991 | -112.363 | 317 | 225.55 | 16 | 81.53 | 53.34 |
| USW00003192 | SCOTTSDALE MUNICIPAL AIRPORT, AZ US | 33.62278 | -111.91056 | 449 | 260.86 |  | 91.44 | 57.91 |
| USC00022782 | EAST MESA, AZ US | 33.4191 | -111.6444 | 462.7 | 295.91 |  | 106.43 | 70.61 |
| USC00025700 | MORMON FLAT, AZ US | 33.5544 | -111.4425 | 519.7 | 353.82 | 28 | 134.62 | 80.26 |
| USC00025467 | MESA, AZ US | 33.4114 | -111.8183 | 376.4 | 241.05 | 16 | 87.12 | 57.66 |
| USC00020288 | APACHE JUNCTION 5 NE, AZ US | 33.4625 | -111.4813 | 630.9 | 337.31 | 27 | 123.7 | 72.39 |
| USC00021282 | CAREFREE, AZ US | 33.8161 | -111.9019 | 771.1 | 331.98 | 31 | 128.52 | 63.75 |
| USC00029634 | YOUNGTOWN, AZ US | 33.595 | -112.3014 | 345.9 | 232.16 | 16 | 85.6 | 54.86 |
| USC00028214 | STEWART MOUNTAIN DAM, AZ US | 33.5575 | -111.5358 | 433.4 | 338.84 | 29 | 124.97 | 75.95 |
| USC00028499 | TEMPE ASU, AZ US | 33.4258 | -111.9216 | 355.7 | 236.98 | 14 | 84.84 | 62.23 |
| USC00028598 | TOLLESON 1 E, AZ US | 33.4519 | -112.2433 | 312.4 | 240.28 | 10 | 90.68 | 59.18 |

**Note:** ANN-PRCP-NORMAL refers long-term averages of annual precipitation totals, ANN-PRCP-AVGNDS-GE100HI refers long-

term averages of number of days during the year with precipitation ≥ 1 inches, DJF-PRCP-NORMAL refers long-term averages of

seasonal precipitation totals for December-February, and JJA-PRCP-NORMAL refers long-term averages of seasonal precipitation

totals for June-August (<https://www.ncdc.noaa.gov/cdo-web/>).

2

**Supplementary Table 2.** Correlation matrix (and scatterplot) between the 10Be denudation rate and catchment variables.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Denudation rate | | Mean elevation | Mean slope | Basin area | Basin relief |
| Denudation rate | 1 |  |  |  |  |
| Mean elevation | 0.69\*\*\* | 1 |  |  |  |
| Mean slope | 0.13 | 0.08 | 1 |  |  |
| Basin area | -0.13 | -0.23 | -0.08 | 1 |  |
| Basin relief | 0.16 | 0.02 | 0.79\*\*\* | 0.2 | 1 |

\*\*\*Significant at p < 0.001.

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**Supplementary Table 3.** T test results for Main Fig. 5.

|  |  |  |
| --- | --- | --- |
| Sonoran Desert,  AZ | | Inactive/Arid |
| Mean | 20.628 | 18.89832895 |
| Variance | 231.8564576 | 129.1661638 |
| Observations | 35 | 38 |
| Hypothesized Mean Difference | 0 |  |
| df | 63 |  |
| t Stat | 0.546326279 |  |
| P(T<=t) one-tail | 0.293385673 |  |
| t Critical one-tail | 1.669402222 |  |
| P(T<=t) two-tail | 0.586771346 |  |
| t Critical two-tail | 1.998340543 |  |

|  |  |  |
| --- | --- | --- |
|  | Sonoran Desert, AZ | Inactive/Semi- arid |
| Mean | 20.628 | 47.59466232 |
| Variance | 231.8564576 | 3129.879098 |
| Observations | 35 | 93 |
| Hypothesized Mean Difference | 0 |  |
| df | 119 |  |
| t Stat | -4.249006575 |  |
| P(T<=t) one-tail | 2.14413E-05 |  |
| t Critical one-tail | 1.657759285 |  |
| P(T<=t) two-tail | 4.28827E-05 |  |
| t Critical two-tail | 1.980099876 |  |

|  |  |  |
| --- | --- | --- |
|  | Sonoran Desert, AZ | Active/Arid |
| Mean | 20.628 | 93.57633796 |
| Variance | 231.8564576 | 10845.64367 |
| Observations | 35 | 79 |
| Hypothesized Mean Difference | 0 |  |
| df | 85 |  |
| t Stat | -6.080905533 |  |
| P(T<=t) one-tail | 1.64706E-08 |  |
| t Critical one-tail | 1.6629785 |  |

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|  |  |
| --- | --- |
| P(T<=t) two-tail | 3.29411E-08 |
| t Critical two-tail | 1.988267907 |

|  |  |  |
| --- | --- | --- |
|  | Sonoran Desert, AZ | Active/Semi- arid |
| Mean | 20.628 | 175.3543097 |
| Variance | 231.8564576 | 51842.86334 |
| Observations | 35 | 19 |
| Hypothesized Mean Difference | 0 |  |
| df | 18 |  |
| t Stat | -2.958488758 |  |
| P(T<=t) one-tail | 0.004205215 |  |
| t Critical one-tail | 1.734063607 |  |
| P(T<=t) two-tail | 0.00841043 |  |
| t Critical two-tail | 2.10092204 |  |

|  |  |  |
| --- | --- | --- |
|  | Granitic | Basaltic |
| Mean | 25.69772727 | 6.686 |
| Variance | 281.3424946 | 2.52188 |
| Observations | 22 | 5 |
| Hypothesized Mean Difference | 0 |  |
| df | 23 |  |
| t Stat | 5.214533289 |  |
| P(T<=t) one-tail | 1.37204E-05 |  |
| t Critical one-tail | 1.713871528 |  |
| P(T<=t) two-tail | 2.74408E-05 |  |
| t Critical two-tail | 2.06865761 |  |

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| --- | --- | --- |
|  | Granitic | Metavolcanic |
| Mean | 25.69772727 | 14.56 |
| Variance | 281.3424946 | 8.713 |
| Observations | 22 | 5 |
| Hypothesized Mean Difference | 0 |  |
| df | 25 |  |
| t Stat | 2.921799388 |  |
| P(T<=t) one-tail | 0.003640163 |  |

5

|  |  |
| --- | --- |
| t Critical one-tail | 1.708140761 |
| P(T<=t) two-tail | 0.007280325 |
| t Critical two-tail | 2.059538553 |

|  |  |  |
| --- | --- | --- |
|  | Granitic | Others |
| Mean | 25.697727 | 16.8 |
| Variance | 281.34249 | 82.29 |
| Observations | 22 | 3 |
| Hypothesized Mean Difference | 0 |  |
| df | 4 |  |
| t Stat | 1.403031 |  |
| P(T<=t) one-tail | 0.1166316 |  |
| t Critical one-tail | 2.1318468 |  |
| P(T<=t) two-tail | 0.2332633 |  |
| t Critical two-tail | 2.7764451 |  |

|  |  |  |
| --- | --- | --- |
|  | Granitic | B+Mv+O |
| Mean | 25.697727 | 12.048462 |
| Variance | 281.34249 | 37.714164 |
| Observations | 22 | 13 |
| Hypothesized Mean Difference | 0 |  |
| df | 29 |  |
| t Stat | 3.4459291 |  |
| P(T<=t) one-tail | 0.0008783 |  |
| t Critical one-tail | 1.699127 |  |
| P(T<=t) two-tail | 0.0017567 |  |
| t Critical two-tail | 2.0452296 |  |

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**Denudation Rate (m/My)**

**Supplementary Table 4.** Sample basin location data

**Supplementary Table 5**. Beryllium isotope data

**\*Supplementary Table 4 and Supplementary Table 5 are provided as excel spreadsheets.**

**Supplementary Fig. 1.** Scatter graph of all catchments comparing mean elevation, catchment average slope, drainage area, relief, and 10Be denudation rate. Linear regression models also presented.



Mean Elevation vs. Denudation Rate

90

80

70

60

50

40

30

20

10

0

400

500

600

700

**Mean Elevation (m)**

800

900

1000

**Denudation Rate (m/My)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  | y = | 0.0873x - 36.3 | 32 |  |
|  |  |  | R² = 0.4801 |  |  |
|  |  |  |  |  |  |
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|  |  |  |  |  |
|  |  |  | y = 0.2836x | + 18.416 |
|  |  |  | R² = 0. | 0162 |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

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Mean Slope vs. Denudation Rate

90

80

70

60

50

40

30

20

10

0

0

5

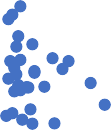
10

15

20

25

**Mean Slope (degree)**



Basin Area vs. Denudation Rate

90

80

70

60

50

40

30

20

10

0

0

5

10

15

20

**Basin Area (km2)**

25

30

35

40

**Denudation Rate (m/My)**

**Denudation Rate (m/My)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  | y = -0 | .3552x + 2 | 1.463 |  |
|  |  |  |  |  | R² = 0.016 | 6 |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |

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| --- | --- | --- | --- | --- | --- | --- | --- |
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|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  | y = 0.0213 | x + 17.40 | 8 |
|  |  |  |  |  | R² = 0 | .0245 |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |

**Supplementary Materials References:**



Basin Relief vs. Denudation Rate

90

80

70

60

50

40

30

20

10

0

0

50

100

150

200

**Basin Relief (m)**

250

300

350

400

Arguez, A., Durre, I., Applequist, S., Squires, M., Vose, R., Yin, X., Bilotta, R., 2010. NOAA's

U.S. Climate Normals (1981-2010). NOAA National Centers for Environmental Information. https://doi.org/10.7289/V5PN93JP (last accessed 9th December 2020).

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