**Table S3.** REE, Y and Ba concentrations in acetic acid leachates and volcaniclastic reference sample from the Greater Karatau Mountains.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sample | Element contents (ppm) |  |  |  |  |  |
|  | La | Ce | Pr | Nd | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu | Y | Ba | ΣREE | (Ce/Ce\*)SN | (Eu/Eu\*)SN | (Dy/Yb)SN | Y/Ho |
| Deepwater micrites |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| AK-06 | 1.01 | 1.76 | 0.23 | 0.86 | 0.18 | 0.05 | 0.18 | 0.029 | 0.183 | 0.042 | 0.125 | 0.017 | 0.113 | 0.019 | 1.84 | 23.7 | 4.74 | 0.85 | 1.39 | 0.92 | 44 |
| AK-10 | 1.43 | 1.60 | 0.27 | 1.19 | 0.24 | 0.06 | 0.32 | 0.047 | 0.307 | 0.071 | 0.197 | 0.028 | 0.161 | 0.025 | 3.70 | 18.1 | 5.95 | 0.62 | 1.12 | 1.08 | 52 |
| AK-11 | 3.82 | 4.19 | 0.81 | 3.07 | 0.68 | 0.17 | 0.70 | 0.127 | 0.813 | 0.184 | 0.538 | 0.072 | 0.478 | 0.077 | 9.15 | 14.2 | 15.76 | 0.57 | 1.26 | 0.96 | 50 |
| ZE-01 | 3.50 | 5.72 | 0.84 | 3.00 | 0.68 | 0.19 | 0.75 | 0.120 | 0.752 | 0.157 | 0.425 | 0.060 | 0.371 | 0.051 | 5.65 | 21.8 | 16.62 | 0.80 | 1.40 | 1.15 | 36 |
| ZH-04 | 1.35 | 1.13 | 0.21 | 0.87 | 0.17 | 0.04 | 0.22 | 0.034 | 0.238 | 0.056 | 0.174 | 0.023 | 0.145 | 0.021 | 2.67 | 4.8 | 4.68 | 0.50 | 1.08 | 0.93 | 48 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Shallow water micrites |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| AK-02 | 3.28 | 6.22 | 0.69 | 2.89 | 0.52 | 0.13 | 0.46 | 0.072 | 0.410 | 0.091 | 0.243 | 0.044 | 0.308 | 0.047 | 3.03 | 19.7 | 15.39 | 0.99 | 1.37 | 0.75 | 33 |
| BE-02 | 1.17 | 2.05 | 0.25 | 0.91 | 0.18 | 0.03 | 0.18 | 0.025 | 0.150 | 0.030 | 0.064 | 0.010 | 0.064 | 0.009 | 1.08 | 2.0 | 5.12 | 0.91 | 1.03 | 1.33 | 36 |
| US-04 | 2.00 | 4.14 | 0.46 | 1.78 | 0.35 | 0.08 | 0.35 | 0.048 | 0.302 | 0.063 | 0.188 | 0.028 | 0.175 | 0.026 | 1.85 | 2.6 | 9.99 | 1.04 | 1.21 | 0.98 | 29 |
| US-09 | 0.82 | 1.56 | 0.20 | 0.77 | 0.15 | 0.03 | 0.15 | 0.022 | 0.138 | 0.030 | 0.092 | 0.013 | 0.085 | 0.014 | 1.20 | 3.6 | 4.07 | 0.93 | 1.06 | 0.92 | 40 |
| US-11 | 0.99 | 1.96 | 0.23 | 0.95 | 0.19 | 0.04 | 0.22 | 0.030 | 0.180 | 0.037 | 0.104 | 0.015 | 0.097 | 0.015 | 1.42 | 1.7 | 5.06 | 0.99 | 1.03 | 1.05 | 38 |
| US-16 | 0.79 | 1.66 | 0.19 | 0.74 | 0.14 | 0.03 | 0.15 | 0.021 | 0.135 | 0.030 | 0.088 | 0.012 | 0.084 | 0.012 | 1.16 | 4.0 | 4.08 | 1.03 | 1.09 | 0.91 | 39 |
| ZE-02 | 0.77 | 1.53 | 0.19 | 0.75 | 0.15 | 0.04 | 0.16 | 0.022 | 0.123 | 0.025 | 0.068 | 0.009 | 0.064 | 0.009 | 0.87 | 1.4 | 3.91 | 0.96 | 1.36 | 1.09 | 35 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Tuffite | 34.0 | 64.5 | 8.82 | 32.4 | 7.12 | 1.01 | 6.60 | 1.03 | 5.58 | 0.99 | 2.12 | 0.256 | 1.44 | 0.203 | 28.0 | 404 | 165.9 | 0.86 | 0.44 | 2.59 | 28 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |