

Table S1 Geochemical data of whole-rock samples.

| Sample         | Fe <sub>T</sub><br>(%) | Fe <sup>3+</sup><br>(%) | Fe <sup>2+</sup><br>(%) | Fe <sup>3+</sup> /<br>Fe <sup>2+</sup> | Fe <sub>carb</sub><br>(%) | Fe <sub>ox</sub><br>(%) | Fe <sub>mag</sub><br>(%) | Fe <sub>HR</sub> /<br>Fe <sub>T</sub> | MgO<br>(%) | CaO<br>(%) | Mn<br>(%)          | Ba<br>(µg/g) | Sr<br>(µg/g) | Mn/<br>Sr | Ba/<br>Sr | Th<br>(µg/g) | Sc<br>(µg/g) | TOC<br>(%) |
|----------------|------------------------|-------------------------|-------------------------|--|---------------------------|-------------------------|--------------------------|---------------------------------------|------------|------------|--------------------|--------------|--------------|-----------|-----------|--------------|--------------|------------|
| Y-28 (red)     | 1.66                   | 1.14                    | 0.52                    | 2.17                                   | 0.029                     | 0.052                   | 0.402                    | 0.29                                  | 14.8       | 15.6       | 0.022              | 696          | 53           | 4.2       | 13        | 6.92         | 5.36         | 0.19       |
| Y-27 (red)     | 1.19                   | 0.50                    | 0.69                    | 0.73                                   | 0.041                     | 0.019                   | 0.226                    | 0.24                                  | 16.6       | 19.3       | 0.021              | 3181         | 144          | 1.5       | 22        | 4.99         | 3.81         | 0.24       |
| Y-23 (red)     | 1.29                   | 0.78                    | 0.51                    | 1.54                                   | 0.011                     | 0.059                   | 0.233                    | 0.23                                  | 16.6       | 18.8       | 0.015 <sup>a</sup> | 120          | 36           | 4.1       | 3         | 4.30         | 3.40         | 0.16       |
| Y-22 (red)     | 1.27                   | 0.74                    | 0.53                    | 1.39                                   | 0.021                     | 0.024                   | 0.191                    | 0.18                                  | 17.2       | 16.8       | 0.014 <sup>a</sup> | 2991         | 72           | 1.9       | 41        | 3.99         | 3.42         | 0.13       |
| Y-20 (red)     | 1.25                   | 0.54                    | 0.71                    | 0.76                                   | 0.033                     | 0.014                   | 0.217                    | 0.21                                  | 18.4       | 15.8       | 0.012 <sup>a</sup> | 1543         | 42           | 2.8       | 37        | 3.64         | 3.25         | 0.15       |
| Y-18 (red)     | 0.92                   | 0.28                    | 0.65                    | 0.43                                   | 0.018                     | 0.030                   | 0.197                    | 0.26                                  | 18.6       | 18.6       | 0.014 <sup>a</sup> | 2613         | 47           | 3.0       | 56        | 3.11         | 2.64         | 0.17       |
| Y-16 (red)     | 1.20                   | 0.76                    | 0.44                    | 1.74                                   | 0.013                     | 0.025                   | 0.095                    | 0.11                                  | 17.7       | 15.2       | 0.019              | 1934         | 44           | 4.4       | 44        | 3.59         | 3.05         | 0.11       |
| Y-15 (red)     | 0.78                   | 0.43                    | 0.34                    | 1.26                                   | 0.010                     | 0.021                   | 0.179                    | 0.27                                  | 16.8       | 19.9       | 0.021              | 2663         | 83           | 2.5       | 32        | 3.49         | 3.00         | 0.20       |
| Y-13 (red)     | 1.44                   | 1.01                    | 0.42                    | 2.41                                   | 0.014                     | 0.039                   | 0.266                    | 0.22                                  | 16.5       | 16.9       | 0.022              | 1668         | 69           | 3.3       | 24        | 4.64         | 4.39         | 0.17       |
| Y-11 (red)     | 0.94                   | 0.44                    | 0.50                    | 0.88                                   | 0.016                     | 0.058                   | 0.180                    | 0.27                                  | 16.7       | 18.1       | 0.021              | 4543         | 141          | 1.5       | 32        | 4.86         | 3.68         | 0.07       |
| Y-9 (red)      | 1.07                   | 0.66                    | 0.41                    | 1.59                                   | 0.020                     | 0.041                   | 0.224                    | 0.26                                  | 17.9       | 18.7       | 0.018              | 2961         | 98           | 1.8       | 30        | 3.44         | 3.49         | 0.55       |
| Y-7 (red)      | 0.99                   | 0.45                    | 0.54                    | 0.83                                   | 0.042                     | 0.025                   | 0.148                    | 0.21                                  | 17.5       | 19.3       | 0.019              | 1819         | 67           | 2.8       | 27        | 3.98         | 3.38         | 0.16       |
| Y-6 (red)      | 1.51                   | 1.03                    | 0.48                    | 2.13                                   | 0.022                     | 0.054                   | 0.189                    | 0.17                                  | 16.7       | 17.4       | 0.021              | 1029         | 56           | 3.7       | 18        | 4.80         | 4.01         | 0.22       |
| Y-5 (red)      | 0.88                   | 0.48                    | 0.41                    | 1.17                                   | 0.052                     | 0.017                   | 0.100                    | 0.19                                  | 18.7       | 19.8       | 0.018              | 351          | 34           | 5.2       | 10        | 2.79         | 2.50         | 0.10       |
| Y-3 (red)      | 1.05                   | 0.56                    | 0.49                    | 1.14                                   | 0.033                     | 0.020                   | 0.192                    | 0.23                                  | 17.8       | 19.9       | 0.019              | 155          | 34           | 5.5       | 5         | 3.73         | 3.13         | 0.08       |
| Average (red)  | 1.16                   | 0.65                    | 0.51                    | 1.34                                   | 0.025                     | 0.033                   | 0.203                    | 0.23                                  | 17.2       | 18.0       | 0.018              | 1884         | 68           | 3.2       | 26        | 4.15         | 3.50         | 0.18       |
| Y-24 (grey)    | 0.42                   | 0.05                    | 0.37                    | 0.12                                   | 0.038                     | 0.012                   | 0.042                    | 0.22                                  | 13.0       | 27.3       | 0.030              | 751          | 188          | 1.6       | 4         | 1.22         | 1.13         | 0.22       |
| Y-21 (grey)    | 0.58                   | 0.01                    | 0.57                    | 0.02                                   | 0.028                     | 0.004                   | 0.033                    | 0.11                                  | 18.1       | 19.6       | 0.016              | 3976         | 90           | 1.8       | 44        | 3.33         | 2.79         | 0.13       |
| Y-19 (grey)    | 0.99                   | 0.29                    | 0.70                    | 0.42                                   | 0.057                     | 0.017                   | 0.070                    | 0.15                                  | 17.9       | 18.7       | 0.015 <sup>a</sup> | 2724         | 55           | 2.7       | 50        | 3.26         | 2.72         | 0.13       |
| Y-17 (grey)    | 0.88                   | 0.29                    | 0.59                    | 0.49                                   | 0.032                     | 0.007                   | 0.062                    | 0.11                                  | 17.8       | 15.2       | 0.018              | 12495        | 225          | 0.8       | 56        | 2.85         | 2.68         | 0.08       |
| Y-14 (grey)    | 0.76                   | 0.30                    | 0.46                    | 0.66                                   | 0.052                     | 0.015                   | 0.123                    | 0.25                                  | 15.3       | 16.0       | 0.019              | 3694         | 92           | 2.1       | 40        | 4.85         | 4.26         | 0.09       |
| Y-12 (grey)    | 0.66                   | 0.13                    | 0.53                    | 0.25                                   | 0.058                     | 0.018                   | 0.075                    | 0.23                                  | 14.0       | 16.6       | 0.022              | 20743        | 443          | 0.5       | 47        | 4.30         | 3.56         | 0.16       |
| Y-10 (grey)    | 0.48                   | 0.04                    | 0.44                    | 0.08                                   | 0.014                     | 0.018                   | 0.080                    | 0.23                                  | 17.5       | 19.1       | 0.018              | 6101         | 179          | 1.0       | 34        | 3.08         | 2.36         | 0.09       |
| Y-8 (grey)     | 0.48                   | 0.02                    | 0.46                    | 0.05                                   | 0.026                     | 0.007                   | 0.051                    | 0.18                                  | 18.6       | 19.3       | 0.016              | 805          | 46           | 3.4       | 18        | 3.00         | 2.44         | 0.19       |
| Y-4 (grey)     | 0.34                   | 0.01                    | 0.33                    | 0.03                                   | 0.024                     | 0.009                   | 0.025                    | 0.17                                  | 18.0       | 23.7       | 0.026              | 2110         | 99           | 2.7       | 21        | 1.52         | 1.40         | 0.14       |
| Y-2 (grey)     | 0.11                   | 0.02 <sup>a</sup>       | 0.09 <sup>a</sup>       | 0.23                                   | 0.017                     | 0.002                   | 0.012                    | 0.27                                  | 21.6       | 30.1       | 0.029              | 75           | 41           | 7.2       | 2         | 0.14         | 0.43         | 0.13       |
| Y-1 (grey)     | 1.00                   | 0.19                    | 0.81                    | 0.23                                   | 0.055                     | 0.011                   | 0.114                    | 0.18                                  | 18.9       | 18.6       | 0.015 <sup>a</sup> | 636          | 42           | 3.5       | 15        | 3.86         | 3.26         | 0.08       |
| Average (grey) | 0.61                   | 0.12                    | 0.49                    | 0.23                                   | 0.037                     | 0.011                   | 0.062                    | 0.19                                  | 17.3       | 20.4       | 0.020              | 4919         | 136          | 2.4       | 30        | 2.86         | 2.46         | 0.13       |
| Average        | 0.93                   | 0.43                    | 0.50                    | 0.88                                   | 0.03                      | 0.024                   | 0.143                    | 0.21                                  | 17.3       | 19.0       | 0.019              | 3168         | 97           | 2.9       | 28        | 3.60         | 3.06         | 0.16       |
| PAAS           | -                      | -                       | -                       | -                                      | -                         | -                       | -                        | -                                     | -          | -          | -                  | -            | -            | -         | -         | 14.6         | 16           | -          |

Table S1 (continued)

| Sample         | Mo<br>(µg/g) | U<br>(µg/g) | Zn<br>(µg/g) | Cu<br>(µg/g) | Ni<br>(µg/g) | Cr<br>(µg/g) | Co<br>(µg/g) | Mo <sub>EF</sub> | U <sub>EF</sub> | Zn <sub>EF</sub> | Cu <sub>EF</sub> | Ni <sub>EF</sub> | Cr <sub>EF</sub> | Co <sub>EF</sub> |
|----------------|--------------|-------------|--------------|--------------|--------------|--------------|--------------|------------------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Y-28 (red)     | 0.334        | 1.56        | 23.9         | 6.77         | 15.1         | 61.5         | 5.88         | 0.705            | 1.062           | 0.593            | 0.286            | 0.579            | 1.180            | 0.539            |
| Y-27 (red)     | 0.310        | 1.30        | 21.4         | 4.31         | 14.2         | 43.1         | 4.93         | 0.907            | 1.227           | 0.737            | 0.252            | 0.755            | 1.146            | 0.627            |
| Y-23 (red)     | 0.291        | 0.99        | 18.8         | 10.1         | 14.1         | 46.5         | 4.04         | 0.988            | 1.085           | 0.751            | 0.686            | 0.870            | 1.435            | 0.596            |
| Y-22 (red)     | 0.187        | 1.56        | 17.1         | 5.69         | 15.6         | 60.9         | 4.40         | 0.684            | 1.841           | 0.736            | 0.416            | 1.038            | 2.026            | 0.700            |
| Y-20 (red)     | 0.127        | 1.15        | 16.1         | 2.29         | 14.5         | 31.3         | 4.17         | 0.509            | 1.488           | 0.760            | 0.184            | 1.057            | 1.141            | 0.727            |
| Y-18 (red)     | 0.139        | 0.91        | 16.9         | 3.82         | 12.7         | 40.5         | 3.44         | 0.653            | 1.375           | 0.933            | 0.359            | 1.084            | 1.728            | 0.702            |
| Y-16 (red)     | 0.330        | 1.41        | 15.8         | 14.2         | 18.6         | 142          | 4.87         | 1.342            | 1.850           | 0.756            | 1.155            | 1.375            | 5.250            | 0.861            |
| Y-15 (red)     | 0.221        | 0.93        | 31.8         | 6.16         | 14.0         | 54.0         | 4.21         | 0.925            | 1.250           | 1.565            | 0.515            | 1.065            | 2.054            | 0.766            |
| Y-13 (red)     | 0.263        | 1.37        | 19.7         | 6.88         | 15.9         | 72.4         | 5.67         | 0.828            | 1.391           | 0.729            | 0.433            | 0.910            | 2.071            | 0.776            |
| Y-11 (red)     | 0.272        | 1.21        | 21.2         | 13.0         | 18.7         | 112          | 5.35         | 0.817            | 1.173           | 0.749            | 0.781            | 1.021            | 3.059            | 0.699            |
| Y-9 (red)      | 0.178        | 1.34        | 19.9         | 6.99         | 14.5         | 67.0         | 4.39         | 0.755            | 1.835           | 0.994            | 0.593            | 1.119            | 2.585            | 0.810            |
| Y-7 (red)      | 0.225        | 1.09        | 15.4         | 7.36         | 15.3         | 73.4         | 4.73         | 0.825            | 1.290           | 0.665            | 0.540            | 1.020            | 2.448            | 0.754            |
| Y-6 (red)      | 0.244        | 1.38        | 18.1         | 11.7         | 17.3         | 103          | 5.13         | 0.742            | 1.354           | 0.648            | 0.712            | 0.957            | 2.848            | 0.678            |
| Y-5 (red)      | 0.160        | 1.55        | 12.6         | 5.47         | 13.1         | 45.9         | 3.26         | 0.837            | 2.616           | 0.776            | 0.572            | 1.246            | 2.184            | 0.742            |
| Y-3 (red)      | 0.174        | 0.87        | 15.4         | 6.80         | 15.5         | 61.0         | 4.21         | 0.681            | 1.102           | 0.709            | 0.532            | 1.103            | 2.171            | 0.716            |
| Average (red)  | 0.230        | 1.24        | 18.9         | 7.44         | 15.3         | 67.6         | 4.58         | 0.813            | 1.463           | 0.807            | 0.534            | 1.013            | 2.222            | 0.713            |
| Y-24 (grey)    | 0.142        | 0.35        | 12.6         | 4.12         | 16.0         | 34.4         | 2.82         | 1.699            | 1.367           | 1.774            | 0.986            | 3.481            | 3.742            | 1.467            |
| Y-21 (grey)    | 0.142        | 1.25        | 14.3         | 4.22         | 17.0         | 44.0         | 3.68         | 0.623            | 1.768           | 0.738            | 0.370            | 1.355            | 1.754            | 0.702            |
| Y-19 (grey)    | 0.112        | 0.79        | 12.5         | 4.00         | 16.0         | 41.5         | 3.55         | 0.502            | 1.138           | 0.659            | 0.358            | 1.303            | 1.690            | 0.691            |
| Y-17 (grey)    | 0.315        | 1.22        | 18.6         | 17.2         | 18.1         | 166          | 4.52         | 1.614            | 2.016           | 1.121            | 1.762            | 1.686            | 7.731            | 1.007            |
| Y-14 (grey)    | 0.173        | 0.96        | 21.5         | 6.43         | 15.6         | 57.6         | 4.90         | 0.521            | 0.932           | 0.761            | 0.387            | 0.854            | 1.576            | 0.641            |
| Y-12 (grey)    | 0.223        | 1.87        | 20.5         | 42.8         | 13.9         | 42.3         | 3.45         | 0.757            | 2.048           | 0.819            | 2.906            | 0.858            | 1.306            | 0.509            |
| Y-10 (grey)    | 0.216        | 0.92        | 15.7         | 11.2         | 15.3         | 82.3         | 3.83         | 1.024            | 1.411           | 0.876            | 1.062            | 1.319            | 3.547            | 0.789            |
| Y-8 (grey)     | 0.155        | 0.68        | 17.0         | 4.74         | 13.3         | 30.4         | 3.62         | 0.754            | 1.072           | 0.973            | 0.461            | 1.177            | 1.345            | 0.766            |
| Y-4 (grey)     | 0.276        | 0.31        | 9.8          | 16.8         | 17.3         | 121          | 2.78         | 2.651            | 0.964           | 1.103            | 3.227            | 3.021            | 10.566           | 1.161            |
| Y-1 (grey)     | 0.135        | 0.91        | 16.6         | 3.03         | 12.5         | 33.2         | 3.93         | 0.511            | 1.109           | 0.739            | 0.229            | 0.860            | 1.142            | 0.646            |
| Average (grey) | 0.189        | 0.93        | 15.9         | 11.1         | 15.5         | 65.3         | 3.71         | 1.066            | 1.383           | 0.956            | 1.175            | 1.591            | 3.440            | 0.838            |
| Average        | 0.214        | 1.12        | 17.7         | 9.04         | 15.4         | 66.7         | 4.23         | 0.914            | 1.431           | 0.866            | 0.791            | 1.245            | 2.709            | 0.763            |
| PAAS           | 1            | 3.1         | 85           | 50           | 55           | 110          | 23           | -                | -               | -                | -                | -                | -                | -                |

Table S1 (continued)

| Sample         | La<br>(µg/g) | Ce<br>(µg/g) | Pr<br>(µg/g) | Nd<br>(µg/g) | Sm<br>(µg/g) | Eu<br>(µg/g) | Gd<br>(µg/g) | Tb<br>(µg/g) | Dy<br>(µg/g) | Y<br>(µg/g) | Ho<br>(µg/g) | Er<br>(µg/g) | Tm<br>(µg/g) | Yb<br>(µg/g) | Lu<br>(µg/g) | Ce/Ce* | Eu/Eu* | Y/Ho | (Dy/<br>Sm) <sub>SN</sub> | REE<br>(µg/g) |
|----------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|--------------|--------------|--------------|--------------|--------------|--------|--------|------|---------------------------|---------------|
| Y-28 (red)     | 17.8         | 35.2         | 3.88         | 14.4         | 2.51         | 0.42         | 2.25         | 0.42         | 2.40         | 14.1        | 0.50         | 1.45         | 0.27         | 1.63         | 0.23         | 0.97   | 0.81   | 28.2 | 1.13                      | 97.46         |
| Y-27 (red)     | 13.6         | 25.3         | 3.05         | 11.30        | 2.01         | 0.39         | 1.73         | 0.31         | 1.67         | 9.43        | 0.33         | 0.90         | 0.16         | 1.05         | 0.15         | 0.89   | 0.96   | 28.6 | 0.99                      | 71.38         |
| Y-23 (red)     | 12.4         | 21.1         | 2.79         | 10.5         | 1.94         | 0.30         | 1.65         | 0.29         | 1.65         | 9.16        | 0.32         | 0.89         | 0.15         | 0.96         | 0.14         | 0.82   | 0.78   | 28.6 | 1.01                      | 64.24         |
| Y-22 (red)     | 11.7         | 21.4         | 2.49         | 9.19         | 1.67         | 0.33         | 1.46         | 0.25         | 1.33         | 7.47        | 0.26         | 0.73         | 0.13         | 0.81         | 0.12         | 0.92   | 0.99   | 28.7 | 0.94                      | 59.34         |
| Y-20 (red)     | 10.9         | 19.7         | 2.27         | 8.35         | 1.44         | 0.27         | 1.28         | 0.21         | 1.20         | 6.72        | 0.24         | 0.65         | 0.11         | 0.70         | 0.10         | 0.92   | 0.95   | 28.0 | 0.99                      | 54.14         |
| Y-18 (red)     | 9.3          | 16.9         | 1.99         | 7.38         | 1.34         | 0.28         | 1.14         | 0.20         | 1.12         | 6.11        | 0.21         | 0.60         | 0.11         | 0.67         | 0.09         | 0.91   | 1.05   | 29.1 | 0.99                      | 47.47         |
| Y-16 (red)     | 10.2         | 18.4         | 2.14         | 8.13         | 1.49         | 0.26         | 1.26         | 0.22         | 1.16         | 6.67        | 0.24         | 0.67         | 0.12         | 0.71         | 0.11         | 0.94   | 0.88   | 27.8 | 0.92                      | 51.78         |
| Y-15 (red)     | 10.1         | 18.9         | 2.25         | 8.39         | 1.52         | 0.32         | 1.35         | 0.24         | 1.28         | 7.17        | 0.25         | 0.71         | 0.12         | 0.75         | 0.11         | 0.91   | 1.04   | 28.7 | 1.00                      | 53.46         |
| Y-13 (red)     | 12.9         | 22.7         | 2.80         | 10.4         | 1.81         | 0.34         | 1.64         | 0.28         | 1.48         | 8.71        | 0.30         | 0.85         | 0.15         | 0.96         | 0.14         | 0.87   | 0.93   | 29.0 | 0.97                      | 65.46         |
| Y-11 (red)     | 13.5         | 25.2         | 3.01         | 11.40        | 2.11         | 0.43         | 1.74         | 0.30         | 1.71         | 9.34        | 0.33         | 0.92         | 0.16         | 0.98         | 0.15         | 0.92   | 1.04   | 28.3 | 0.96                      | 71.28         |
| Y-9 (red)      | 10.9         | 18.8         | 2.33         | 8.71         | 1.60         | 0.61         | 1.43         | 0.24         | 1.30         | 6.87        | 0.25         | 0.71         | 0.12         | 0.72         | 0.10         | 0.87   | 1.91   | 27.5 | 0.96                      | 54.69         |
| Y-7 (red)      | 11.5         | 20.1         | 2.38         | 8.79         | 1.51         | 0.63         | 1.37         | 0.25         | 1.36         | 7.81        | 0.27         | 0.75         | 0.13         | 0.82         | 0.12         | 0.90   | 2.02   | 28.9 | 1.07                      | 57.79         |
| Y-6 (red)      | 14.7         | 28.3         | 3.20         | 12.0         | 2.03         | 0.55         | 1.81         | 0.33         | 1.81         | 9.73        | 0.35         | 0.97         | 0.17         | 1.03         | 0.15         | 0.96   | 1.32   | 27.8 | 1.06                      | 77.13         |
| Y-5 (red)      | 7.2          | 14.3         | 1.62         | 5.97         | 1.03         | 0.27         | 0.96         | 0.17         | 0.94         | 5.28        | 0.19         | 0.52         | 0.10         | 0.55         | 0.08         | 0.94   | 1.27   | 27.8 | 1.08                      | 39.22         |
| Y-3 (red)      | 10.7         | 21.2         | 2.32         | 8.69         | 1.50         | 0.29         | 1.39         | 0.24         | 1.33         | 7.23        | 0.26         | 0.72         | 0.13         | 0.77         | 0.11         | 0.99   | 0.95   | 27.8 | 1.05                      | 56.88         |
| Average (red)  | 11.8         | 21.8         | 2.6          | 9.6          | 1.7          | 0.4          | 1.5          | 0.3          | 1.4          | 8.1         | 0.3          | 0.8          | 0.1          | 0.9          | 0.1          | 0.92   | 1.13   | 28.3 | 1.01                      | 61.4          |
| Y-24 (grey)    | 5.9          | 9.3          | 1.22         | 4.71         | 0.88         | 0.17         | 0.76         | 0.14         | 0.81         | 5.11        | 0.16         | 0.45         | 0.08         | 0.45         | 0.07         | 0.85   | 0.95   | 31.9 | 1.09                      | 30.19         |
| Y-21 (grey)    | 9.9          | 18.4         | 2.16         | 8.02         | 1.45         | 0.33         | 1.25         | 0.22         | 1.14         | 6.59        | 0.24         | 0.64         | 0.11         | 0.71         | 0.10         | 0.91   | 1.14   | 27.5 | 0.93                      | 51.28         |
| Y-19 (grey)    | 9.5          | 17.5         | 2.02         | 7.53         | 1.33         | 0.28         | 1.16         | 0.21         | 1.09         | 6.15        | 0.22         | 0.62         | 0.11         | 0.67         | 0.10         | 0.93   | 1.04   | 28.0 | 0.97                      | 48.50         |
| Y-17 (grey)    | 8.5          | 15.3         | 1.81         | 6.80         | 1.22         | 0.50         | 1.10         | 0.18         | 0.99         | 5.43        | 0.19         | 0.54         | 0.10         | 0.55         | 0.09         | 0.92   | 2.07   | 28.6 | 0.96                      | 43.28         |
| Y-14 (grey)    | 12.3         | 23.6         | 2.83         | 10.3         | 1.76         | 0.40         | 1.51         | 0.26         | 1.39         | 7.56        | 0.28         | 0.80         | 0.15         | 0.88         | 0.13         | 0.88   | 1.15   | 27.0 | 0.94                      | 64.15         |
| Y-12 (grey)    | 13.2         | 23.6         | 2.77         | 10.3         | 1.81         | 0.71         | 1.64         | 0.27         | 1.43         | 7.59        | 0.28         | 0.78         | 0.14         | 0.85         | 0.12         | 0.92   | 1.97   | 27.1 | 0.94                      | 65.49         |
| Y-10 (grey)    | 9.3          | 17.3         | 2.05         | 7.60         | 1.35         | 0.40         | 1.21         | 0.20         | 1.13         | 6.48        | 0.22         | 0.63         | 0.10         | 0.66         | 0.10         | 0.90   | 1.49   | 29.5 | 0.99                      | 48.75         |
| Y-8 (grey)     | 8.7          | 17.5         | 1.91         | 7.21         | 1.27         | 0.40         | 1.13         | 0.20         | 1.11         | 6.21        | 0.21         | 0.60         | 0.11         | 0.65         | 0.09         | 1.00   | 1.55   | 29.6 | 1.04                      | 47.32         |
| Y-4 (grey)     | 5.6          | 12.9         | 1.39         | 5.35         | 1.05         | 0.27         | 0.86         | 0.16         | 0.86         | 4.90        | 0.17         | 0.44         | 0.08         | 0.44         | 0.06         | 1.03   | 1.28   | 28.8 | 0.97                      | 34.54         |
| Y-1 (grey)     | 9.9          | 18.4         | 2.18         | 8.24         | 1.45         | 0.38         | 1.26         | 0.23         | 1.34         | 7.50        | 0.26         | 0.75         | 0.13         | 0.84         | 0.12         | 0.92   | 1.29   | 28.8 | 1.10                      | 53.02         |
| Average (grey) | 9.3          | 17.4         | 2.0          | 7.6          | 1.4          | 0.4          | 1.2          | 0.2          | 1.1          | 6.4         | 0.2          | 0.6          | 0.1          | 0.7          | 0.1          | 0.93   | 1.39   | 28.7 | 0.99                      | 48.7          |
| Average        | 10.8         | 20.1         | 2.4          | 8.8          | 1.6          | 0.4          | 1.4          | 0.2          | 1.3          | 7.4         | 0.3          | 0.7          | 0.1          | 0.8          | 0.1          | 0.92   | 1.23   | 28.5 | 1.00                      | 56.3          |
| PAAS           | 38.2         | 79.6         | 8.83         | 33.9         | 5.55         | 1.08         | 4.66         | 0.77         | 4.68         | 27.0        | 0.99         | 2.85         | 0.40         | 2.82         | 0.43         | -      | -      | -    | -                         | -             |

<sup>a</sup> Limited to experimental methods and extreme low contents, data values are for reference only.

Table S2 Geochemical data of acetic leached samples.

| Sample         | Th<br>(µg/g) | Mo<br>(µg/g) | U<br>(µg/g) | Zn<br>(µg/g) | Cu<br>(µg/g) | Ni<br>(µg/g) | Cr<br>(µg/g) | Co<br>(µg/g) | Mo <sub>EF</sub> | U <sub>EF</sub> | Zn <sub>EF</sub> | Cu <sub>EF</sub> | Ni <sub>EF</sub> | Cr <sub>EF</sub> | Co <sub>EF</sub> |
|----------------|--------------|--------------|-------------|--------------|--------------|--------------|--------------|--------------|------------------|-----------------|------------------|------------------|------------------|------------------|------------------|
| Y-28 (red)     | 0.62         | 0.23         | 0.23        | 5.66         | 3.57         | 3.85         | 3.97         | 0.69         | 5.49             | 1.75            | 1.57             | 1.68             | 1.65             | 0.85             | 0.71             |
| Y-27 (red)     | 0.49         | 0.22         | 0.21        | 3.99         | 3.23         | 3.83         | 3.14         | 0.69         | 6.44             | 2.00            | 1.40             | 1.93             | 2.08             | 0.85             | 0.89             |
| Y-23 (red)     | 0.48         | 0.21         | 0.18        | 3.35         | 3.47         | 6.72         | 3.56         | 0.60         | 6.58             | 1.79            | 1.21             | 2.13             | 3.75             | 0.99             | 0.80             |
| Y-22 (red)     | 0.34         | 0.26         | 0.21        | 2.98         | 3.44         | 3.51         | 4.23         | 0.42         | 11.24            | 2.94            | 1.51             | 2.97             | 2.76             | 1.66             | 0.79             |
| Y-20 (red)     | 0.36         | 0.28         | 0.21        | 3.12         | 3.57         | 3.55         | 3.92         | 0.44         | 11.33            | 2.71            | 1.50             | 2.91             | 2.63             | 1.45             | 0.77             |
| Y-18 (red)     | 0.39         | 0.32         | 0.23        | 3.47         | 3.91         | 3.89         | 4.47         | 0.40         | 12.00            | 2.75            | 1.51             | 2.89             | 2.61             | 1.50             | 0.65             |
| Y-16 (red)     | 0.39         | 0.30         | 0.23        | 3.35         | 3.94         | 2.58         | 3.92         | 0.42         | 11.30            | 2.75            | 1.48             | 2.95             | 1.76             | 1.33             | 0.68             |
| Y-15 (red)     | 0.49         | 0.28         | 0.21        | 3.35         | 3.93         | 3.87         | 4.44         | 0.56         | 8.35             | 2.04            | 1.18             | 2.35             | 2.11             | 1.21             | 0.73             |
| Y-13 (red)     | 0.66         | 0.29         | 0.26        | 3.70         | 3.79         | 4.30         | 4.57         | 0.72         | 6.46             | 1.85            | 0.97             | 1.69             | 1.74             | 0.93             | 0.70             |
| Y-11 (red)     | 0.51         | 0.23         | 0.21        | 2.97         | 3.11         | 3.23         | 3.30         | 0.57         | 6.41             | 1.94            | 0.99             | 1.76             | 1.66             | 0.85             | 0.71             |
| Y-9 (red)      | 0.46         | 0.21         | 0.20        | 2.66         | 2.73         | 3.40         | 4.65         | 0.54         | 6.70             | 2.04            | 1.00             | 1.75             | 1.98             | 1.35             | 0.75             |
| Y-7 (red)      | 0.59         | 0.36         | 0.22        | 3.67         | 3.55         | 4.65         | 4.98         | 0.58         | 8.93             | 1.72            | 1.07             | 1.76             | 2.09             | 1.12             | 0.63             |
| Y-6 (red)      | 0.52         | 0.35         | 0.23        | 3.67         | 4.05         | 4.08         | 5.01         | 1.04         | 9.74             | 2.06            | 1.22             | 2.28             | 2.08             | 1.28             | 1.27             |
| Y-5 (red)      | 0.49         | 0.26         | 0.21        | 3.10         | 3.25         | 4.38         | 3.28         | 0.50         | 7.75             | 1.97            | 1.08             | 1.92             | 2.36             | 0.88             | 0.64             |
| Y-3 (red)      | 0.61         | 0.27         | 0.22        | 3.70         | 4.07         | 5.10         | 5.30         | 0.90         | 6.57             | 1.71            | 1.04             | 1.95             | 2.22             | 1.16             | 0.94             |
| Average (red)  | 0.49         | 0.27         | 0.22        | 3.52         | 3.57         | 4.06         | 4.18         | 0.60         | 8.35             | 2.13            | 1.25             | 2.19             | 2.23             | 1.16             | 0.78             |
| Y-24 (grey)    | 0.33         | 0.47         | 0.21        | 7.02         | 4.46         | 4.53         | 4.73         | 0.42         | 20.56            | 3.01            | 3.61             | 3.90             | 3.60             | 1.88             | 0.80             |
| Y-21 (grey)    | 0.20         | 0.29         | 0.17        | 2.42         | 3.59         | 3.00         | 3.44         | 0.27         | 21.07            | 4.05            | 2.09             | 5.26             | 4.00             | 2.29             | 0.87             |
| Y-19 (grey)    | 0.35         | 0.64         | 0.17        | 3.05         | 3.44         | 3.36         | 4.18         | 0.37         | 27.02            | 2.38            | 1.52             | 2.90             | 2.58             | 1.61             | 0.69             |
| Y-17 (grey)    | 0.31         | 0.27         | 0.19        | 3.22         | 3.56         | 3.86         | 3.67         | 0.38         | 12.62            | 2.94            | 1.77             | 3.33             | 3.29             | 1.56             | 0.78             |
| Y-14 (grey)    | 0.51         | 0.23         | 0.24        | 3.98         | 8.63         | 3.03         | 2.87         | 0.41         | 6.68             | 2.17            | 1.34             | 4.93             | 1.57             | 0.74             | 0.51             |
| Y-12 (grey)    | 0.63         | 0.30         | 0.32        | 5.89         | 11.29        | 4.06         | 4.42         | 0.63         | 6.87             | 2.37            | 1.61             | 5.23             | 1.71             | 0.93             | 0.63             |
| Y-10 (grey)    | 0.32         | 0.28         | 0.21        | 3.54         | 4.14         | 3.74         | 3.53         | 0.45         | 12.53            | 3.00            | 1.87             | 3.72             | 3.05             | 1.44             | 0.87             |
| Y-8 (grey)     | 0.70         | 0.30         | 0.19        | 3.64         | 4.30         | 4.07         | 5.78         | 0.51         | 6.17             | 1.26            | 0.89             | 1.79             | 1.54             | 1.09             | 0.46             |
| Y-4 (grey)     | 0.24         | 0.29         | 0.16        | 3.61         | 4.16         | 3.63         | 6.78         | 0.32         | 17.84            | 3.22            | 2.58             | 5.04             | 4.00             | 3.74             | 0.83             |
| Y-1 (grey)     | 0.50         | 0.25         | 0.18        | 2.81         | 3.68         | 4.10         | 2.40         | 0.43         | 7.40             | 1.71            | 0.97             | 2.16             | 2.19             | 0.64             | 0.55             |
| Average (grey) | 0.41         | 0.33         | 0.20        | 3.92         | 5.12         | 3.74         | 4.18         | 0.42         | 13.88            | 2.61            | 1.82             | 3.83             | 2.75             | 1.59             | 0.70             |
| Average        | 0.46         | 0.30         | 0.21        | 3.68         | 4.19         | 3.93         | 4.18         | 0.53         | 10.56            | 2.33            | 1.48             | 2.85             | 2.44             | 1.33             | 0.75             |
| PAAS           | 14.6         | 1            | 3.1         | 85           | 50           | 55           | 110          | 23           | -                | -               | -                | -                | -                | -                | -                |

Table S2 (continued)

| Sample         | La<br>(µg/g) | Ce<br>(µg/g) | Pr<br>(µg/g) | Nd<br>(µg/g) | Sm<br>(µg/g) | Eu<br>(µg/g) | Gd<br>(µg/g) | Tb<br>(µg/g) | Dy<br>(µg/g) | Y<br>(µg/g) | Ho<br>(µg/g) | Er<br>(µg/g) | Tm<br>(µg/g) | Yb<br>(µg/g) | Lu<br>(µg/g) | Ce/Ce* | Eu/Eu* | Y/Ho  | (Dy/<br>Sm) <sub>SN</sub> | REE<br>(µg/g) |
|----------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|-------------|--------------|--------------|--------------|--------------|--------------|--------|--------|-------|---------------------------|---------------|
| Y-28 (red)     | 3.8          | 8.0          | 0.94         | 3.55         | 0.63         | 0.109        | 0.60         | 0.095        | 0.50         | 2.45        | 0.084        | 0.216        | 0.032        | 0.253        | 0.034        | 0.93   | 0.87   | 29.26 | 0.94                      | 21.32         |
| Y-27 (red)     | 3.3          | 6.8          | 0.83         | 3.02         | 0.55         | 0.121        | 0.50         | 0.089        | 0.44         | 2.37        | 0.071        | 0.207        | 0.029        | 0.199        | 0.031        | 0.86   | 1.07   | 33.44 | 0.95                      | 18.53         |
| Y-23 (red)     | 1.6          | 3.4          | 0.35         | 1.12         | 0.21         | 0.041        | 0.19         | 0.032        | 0.18         | 0.72        | 0.026        | 0.079        | 0.012        | 0.086        | 0.012        | 0.88   | 0.98   | 28.08 | 1.01                      | 8.09          |
| Y-22 (red)     | 2.1          | 4.1          | 0.51         | 1.69         | 0.27         | 0.050        | 0.24         | 0.048        | 0.24         | 1.00        | 0.034        | 0.090        | 0.013        | 0.093        | 0.012        | 0.77   | 0.89   | 29.64 | 1.05                      | 10.42         |
| Y-20 (red)     | 2.6          | 5.6          | 0.63         | 2.11         | 0.37         | 0.091        | 0.37         | 0.063        | 0.31         | 1.61        | 0.053        | 0.167        | 0.023        | 0.151        | 0.019        | 0.86   | 1.17   | 30.39 | 0.99                      | 14.20         |
| Y-18 (red)     | 1.5          | 3.2          | 0.46         | 1.65         | 0.29         | 0.060        | 0.28         | 0.046        | 0.24         | 1.32        | 0.039        | 0.113        | 0.016        | 0.094        | 0.014        | 0.71   | 1.01   | 34.27 | 0.98                      | 9.35          |
| Y-16 (red)     | 2.0          | 3.4          | 0.46         | 1.78         | 0.28         | 0.050        | 0.22         | 0.043        | 0.24         | 1.43        | 0.051        | 0.148        | 0.019        | 0.129        | 0.017        | 0.82   | 0.88   | 28.19 | 1.00                      | 10.25         |
| Y-15 (red)     | 2.0          | 3.2          | 0.45         | 1.53         | 0.29         | 0.057        | 0.26         | 0.044        | 0.24         | 1.41        | 0.042        | 0.130        | 0.017        | 0.105        | 0.014        | 0.71   | 0.98   | 33.42 | 0.97                      | 9.75          |
| Y-13 (red)     | 1.9          | 4.2          | 0.49         | 1.58         | 0.25         | 0.050        | 0.25         | 0.044        | 0.19         | 0.71        | 0.024        | 0.057        | 0.008        | 0.060        | 0.009        | 0.81   | 0.95   | 29.44 | 0.90                      | 9.86          |
| Y-11 (red)     | 1.8          | 3.4          | 0.38         | 1.27         | 0.24         | 0.048        | 0.23         | 0.040        | 0.19         | 1.20        | 0.036        | 0.110        | 0.015        | 0.099        | 0.014        | 0.88   | 0.96   | 33.41 | 0.94                      | 9.05          |
| Y-9 (red)      | 1.2          | 1.9          | 0.27         | 0.98         | 0.16         | 0.042        | 0.15         | 0.025        | 0.14         | 0.82        | 0.026        | 0.078        | 0.011        | 0.066        | 0.009        | 0.73   | 1.29   | 31.06 | 0.99                      | 5.90          |
| Y-7 (red)      | 0.9          | 2.0          | 0.25         | 0.90         | 0.14         | 0.039        | 0.16         | 0.024        | 0.13         | 0.72        | 0.021        | 0.063        | 0.009        | 0.058        | 0.008        | 0.83   | 1.35   | 33.72 | 1.10                      | 5.43          |
| Y-6 (red)      | 2.0          | 4.1          | 0.51         | 1.97         | 0.27         | 0.055        | 0.26         | 0.046        | 0.23         | 1.01        | 0.030        | 0.091        | 0.012        | 0.082        | 0.012        | 0.90   | 0.99   | 33.14 | 1.02                      | 10.65         |
| Y-5 (red)      | 0.8          | 1.5          | 0.17         | 0.60         | 0.11         | 0.028        | 0.10         | 0.017        | 0.09         | 0.51        | 0.018        | 0.048        | 0.007        | 0.046        | 0.006        | 0.91   | 1.26   | 28.37 | 1.02                      | 4.01          |
| Y-3 (red)      | 1.8          | 3.4          | 0.43         | 1.80         | 0.25         | 0.047        | 0.23         | 0.040        | 0.16         | 0.84        | 0.027        | 0.075        | 0.011        | 0.077        | 0.008        | 0.93   | 0.93   | 30.65 | 0.77                      | 9.18          |
| Average (red)  | 2.0          | 3.9          | 0.48         | 1.70         | 0.29         | 0.059        | 0.27         | 0.046        | 0.23         | 1.21        | 0.039        | 0.111        | 0.015        | 0.106        | 0.015        | 0.84   | 1.04   | 31.10 | 0.98                      | 10.40         |
| Y-24 (grey)    | 1.5          | 2.7          | 0.33         | 1.15         | 0.22         | 0.038        | 0.20         | 0.028        | 0.15         | 1.11        | 0.033        | 0.096        | 0.013        | 0.083        | 0.012        | 0.85   | 0.93   | 33.84 | 0.83                      | 7.74          |
| Y-21 (grey)    | 1.2          | 2.3          | 0.28         | 1.00         | 0.16         | 0.031        | 0.14         | 0.024        | 0.15         | 1.01        | 0.031        | 0.085        | 0.013        | 0.096        | 0.014        | 0.85   | 0.97   | 32.39 | 1.12                      | 6.60          |
| Y-19 (grey)    | 0.9          | 1.8          | 0.21         | 0.76         | 0.13         | 0.026        | 0.12         | 0.020        | 0.12         | 0.62        | 0.020        | 0.063        | 0.009        | 0.055        | 0.009        | 0.90   | 0.98   | 30.80 | 1.06                      | 4.95          |
| Y-17 (grey)    | 1.4          | 2.2          | 0.25         | 0.88         | 0.16         | 0.057        | 0.19         | 0.033        | 0.15         | 1.15        | 0.035        | 0.093        | 0.013        | 0.086        | 0.013        | 0.89   | 1.62   | 32.50 | 1.15                      | 6.68          |
| Y-14 (grey)    | 1.9          | 3.8          | 0.42         | 1.40         | 0.25         | 0.055        | 0.22         | 0.038        | 0.23         | 1.67        | 0.049        | 0.155        | 0.022        | 0.143        | 0.019        | 0.90   | 1.10   | 34.19 | 1.09                      | 10.38         |
| Y-12 (grey)    | 2.1          | 3.8          | 0.51         | 2.23         | 0.36         | 0.092        | 0.31         | 0.045        | 0.28         | 2.00        | 0.061        | 0.174        | 0.023        | 0.149        | 0.017        | 0.94   | 1.35   | 32.83 | 0.92                      | 12.13         |
| Y-10 (grey)    | 1.7          | 3.0          | 0.34         | 1.14         | 0.24         | 0.054        | 0.19         | 0.033        | 0.15         | 0.82        | 0.027        | 0.077        | 0.010        | 0.073        | 0.011        | 0.86   | 1.17   | 30.50 | 0.76                      | 7.88          |
| Y-8 (grey)     | 0.6          | 1.6          | 0.16         | 0.58         | 0.10         | 0.025        | 0.11         | 0.017        | 0.10         | 0.58        | 0.016        | 0.040        | 0.006        | 0.042        | 0.006        | 1.02   | 1.16   | 37.40 | 1.19                      | 3.96          |
| Y-4 (grey)     | 0.5          | 1.1          | 0.12         | 0.46         | 0.08         | 0.014        | 0.07         | 0.010        | 0.06         | 0.36        | 0.012        | 0.035        | 0.005        | 0.032        | 0.005        | 1.09   | 0.95   | 29.68 | 0.93                      | 2.94          |
| Y-1 (grey)     | 1.5          | 2.8          | 0.35         | 1.22         | 0.21         | 0.044        | 0.20         | 0.032        | 0.17         | 0.91        | 0.032        | 0.089        | 0.012        | 0.081        | 0.009        | 0.78   | 1.05   | 28.52 | 0.97                      | 7.61          |
| Average (grey) | 1.3          | 2.5          | 0.30         | 1.08         | 0.19         | 0.044        | 0.18         | 0.028        | 0.16         | 1.02        | 0.032        | 0.091        | 0.013        | 0.084        | 0.011        | 0.91   | 1.13   | 32.27 | 1.00                      | 7.09          |
| Average        | 1.7          | 3.3          | 0.40         | 1.46         | 0.25         | 0.053        | 0.23         | 0.039        | 0.20         | 1.13        | 0.036        | 0.103        | 0.014        | 0.097        | 0.013        | 0.86   | 1.07   | 31.6  | 0.99                      | 9.07          |
| PAAS           | 38.2         | 79.6         | 8.83         | 33.9         | 5.55         | 1.08         | 4.66         | 0.774        | 4.68         | 27.00       | 0.991        | 2.85         | 0.405        | 2.820        | 0.433        | -      | -      | -     | -                         | -             |