

1 **Palaeo-environmental evolution of Central Asia during the Cenozoic: New insights from**  
2 **the continental sedimentary archive of the Valley of Lakes (Mongolia)**

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26 **Supplementary Information**

27 **Table S1, S2a/b, S3, S4**

28 **Figure S1, S2, S3**

29 **Table S1:** Mineralogical composition of the sediments from the Tsagaan Ovoo Fm., Hsanda  
 30 Gol Fm. and Loh Fm. (Valley of Lakes, Mongolia) determined by XRD analysis.

| Sample ID         | Position<br>(m) | Feldspat<br>(wt.%) | Illite<br>(wt.%) | Quartz<br>(wt.%) | Hematite<br>(wt.%) | Calcite<br>(wt.%) | SUM<br>(wt.%) |
|-------------------|-----------------|--------------------|------------------|------------------|--------------------|-------------------|---------------|
| HTE/15            | 110.13          | 6.2                | 44.8             | 40.3             | 5.7                | 3.0               | 100.00        |
| HTE/14            | 109.78          | 5.8                | 43.8             | 43.0             | 5.5                | 2.0               | 100.00        |
| HTE/13b           | 108.98          | 5.4                | 41.2             | 43.4             | 6.1                | 4.0               | 100.00        |
| HTE/12            | 107.65          | 2.7                | 17.1             | 22.0             | 2.1                | 56.1              | 100.00        |
| HTE/11b           | 105.78          | 3.9                | 17.3             | 18.2             | 2.1                | 58.6              | 100.00        |
| HTE/11a           | 104.98          | 4.5                | 25.8             | 40.5             | 7.2                | 22.0              | 100.00        |
| HTE/9b            | 101.38          | 4.7                | 22.0             | 30.9             | 4.9                | 37.4              | 100.00        |
| HTE/9a            | 100.97          | 4.9                | 36.9             | 41.9             | 6.3                | 9.9               | 100.00        |
| HTE/8             | 100.40          | 6.0                | 38.2             | 46.2             | 2.6                | 7.0               | 100.00        |
| HTE/7b            | 100.00          | 4.0                | 23.5             | 24.0             | 3.4                | 45.1              | 100.00        |
| HTE/7a            | 98.73           | 5.0                | 34.9             | 45.6             | 6.6                | 8.0               | 100.00        |
| HTE/6             | 97.90           | 6.5                | 30.8             | 41.2             | 5.4                | 16.2              | 100.00        |
| HTE/5a            | 96.83           | 5.6                | 39.4             | 45.3             | 6.3                | 3.4               | 100.00        |
| TAT/33b           | 96.11           | 9.4                | 36.2             | 40.6             | 5.3                | 8.6               | 100.00        |
| HTE/4b            | 94.90           | 6.0                | 40.2             | 44.0             | 7.2                | 2.6               | 100.00        |
| TAT/32d           | 94.71           | 5.8                | 15.4             | 11.7             | 2.6                | 64.5              | 100.00        |
| TGR-C/20b         | 94.61           | 8.7                | 36.8             | 44.4             | 7.6                | 2.4               | 100.00        |
| HTE/3a            | 94.20           | 4.8                | 35.7             | 35.7             | 4.8                | 19.0              | 100.00        |
| TGR-C/20a         | 93.78           | 7.1                | 34.5             | 48.5             | 7.8                | 2.0               | 100.00        |
| TAT/32b           | 93.66           | 8.2                | 36.9             | 40.7             | 6.1                | 8.2               | 100.00        |
| HTE/2b            | 93.63           | 8.0                | 38.5             | 46.0             | 4.9                | 2.6               | 100.00        |
| TGR-C/19b         | 93.36           | 6.8                | 28.6             | 35.3             | 5.3                | 24.0              | 100.00        |
| TAT/31            | 93.07           | 7.9                | 37.7             | 42.4             | 6.0                | 6.1               | 100.00        |
| HTE/2a            | 92.73           | 5.9                | 39.5             | 45.1             | 6.9                | 2.5               | 100.00        |
| TGR-C/19a         | 92.49           | 6.3                | 26.3             | 30.9             | 4.0                | 32.6              | 100.00        |
| TAT/30a           | 92.39           | 8.4                | 39.4             | 43.3             | 7.1                | 1.8               | 100.00        |
| TAT/29b           | 92.09           | 8.8                | 40.3             | 42.5             | 7.3                | 1.1               | 100.00        |
| TGR-C/18          | 91.84           | 6.7                | 27.3             | 33.7             | 4.3                | 28.0              | 100.00        |
| TAT/28            | 91.22           | 6.7                | 26.7             | 25.3             | 4.1                | 37.3              | 100.00        |
| SHG-D/30          | 91.20           | 5.3                | 18.9             | 22.4             | 2.5                | 50.8              | 100.00        |
| TGR-C/17a         | 91.18           | 5.9                | 28.3             | 38.8             | 6.4                | 20.6              | 100.00        |
| TAT/27b           | 91.09           | 8.2                | 37.8             | 38.8             | 6.9                | 8.3               | 100.00        |
| HTE/1d            | 91.07           | 6.1                | 40.2             | 39.2             | 4.7                | 9.9               | 100.00        |
| SHG-D/29a         | 90.82           | 6.3                | 31.2             | 41.0             | 5.7                | 15.9              | 100.00        |
| TAT/27a           | 90.76           | 7.8                | 15.2             | 16.8             | 1.7                | 58.4              | 100.00        |
| HTE/1c            | 90.63           | 5.2                | 18.3             | 14.6             | 1.4                | 60.5              | 100.00        |
| TGR-C/16b         | 90.49           | 8.2                | 34.6             | 47.8             | 7.3                | 2.0               | 100.00        |
| SHG-D/28b         | 90.45           | 7.3                | 26.2             | 32.1             | 4.8                | 29.6              | 100.00        |
| TAT/26            | 90.38           | 8.4                | 21.6             | 26.9             | 2.8                | 40.3              | 100.00        |
| HTE/1b            | 90.07           | 4.8                | 45.0             | 42.3             | 6.2                | 1.7               | 100.00        |
| SHG-D/27b         | 90.05           | 6.9                | 37.4             | 46.0             | 6.3                | 3.4               | 100.00        |
| TAT/25            | 90.01           | 10.0               | 36.5             | 44.3             | 7.0                | 2.3               | 100.00        |
| TAT/24a           | 89.85           | 7.3                | 17.9             | 17.3             | 2.1                | 55.5              | 100.00        |
| HTE/1a            | 89.30           | 3.6                | 17.3             | 12.4             | 2.1                | 64.6              | 100.00        |
| TGR-C/15          | 89.24           | 9.1                | 29.8             | 47.8             | 7.3                | 6.0               | 100.00        |
| TGR-C/14b<br>trav | 88.49           | 4.4                | 12.8             | 15.3             | 1.7                | 65.9              | 100.00        |

|           |       |      |      |      |     |      |        |
|-----------|-------|------|------|------|-----|------|--------|
| TGR-C/14b | 87.96 | 4.7  | 13.6 | 27.9 | 3.9 | 49.8 | 100.00 |
| TAT/22c   | 87.94 | 10.4 | 37.5 | 34.5 | 5.4 | 12.2 | 100.00 |
| TGR-C/13d | 86.91 | 5.9  | 38.8 | 45.2 | 7.1 | 3.0  | 100.00 |
| TAT/22a   | 86.54 | 12.9 | 33.5 | 38.6 | 4.7 | 10.2 | 100.00 |
| TAT/21a   | 86.24 | 11.2 | 47.9 | 32.8 | 7.0 | 1.1  | 100.00 |
| TAT/20b   | 85.94 | 10.1 | 38.5 | 41.9 | 6.7 | 2.7  | 100.00 |
| TGR-C/13b | 85.86 | 11.3 | 39.1 | 41.7 | 5.1 | 2.9  | 100.00 |
| TAT/19a   | 84.92 | 9.5  | 40.6 | 42.6 | 6.3 | 1.0  | 100.00 |
| TGR-C/12  | 84.77 | 12.2 | 29.7 | 30.0 | 4.9 | 23.2 | 100.00 |
| TGR-C/11b | 84.69 | 8.2  | 36.4 | 45.5 | 6.9 | 3.0  | 100.00 |
| TGR-C/11a | 84.32 | 12.1 | 28.2 | 25.1 | 4.4 | 30.2 | 100.00 |
| TGR-C/10b | 84.14 | 6.3  | 10.4 | 13.0 | 2.4 | 67.9 | 100.00 |
| TAT/18a   | 83.87 | 8.4  | 24.0 | 18.2 | 3.5 | 45.9 | 100.00 |
| TAT/17b   | 83.24 | 8.0  | 24.6 | 26.4 | 4.0 | 37.0 | 100.00 |
| TGR-C/10a | 83.24 | 12.1 | 35.6 | 33.7 | 5.4 | 13.2 | 100.00 |
| TGR-C/9   | 82.66 | 12.1 | 32.5 | 26.5 | 5.8 | 23.0 | 100.00 |
| TGR-C/8b  | 82.39 | 11.4 | 42.7 | 36.9 | 6.1 | 3.0  | 100.00 |
| TAT/16a   | 82.11 | 8.7  | 29.0 | 37.9 | 4.2 | 20.2 | 100.00 |
| TAT/15c   | 81.84 | 10.8 | 32.7 | 33.0 | 4.0 | 19.6 | 100.00 |
| TGR-C/8a  | 81.12 | 6.1  | 30.2 | 34.9 | 5.1 | 23.8 | 100.00 |
| TAT/15a   | 80.67 | 9.9  | 35.8 | 33.8 | 4.2 | 16.3 | 100.00 |
| TAT/14b   | 80.09 | 12.5 | 36.9 | 34.8 | 4.4 | 11.4 | 100.00 |
| TGR-C/7b  | 80.01 | 11.9 | 39.8 | 32.2 | 5.5 | 10.5 | 100.00 |
| TAT/13    | 79.24 | 11.3 | 35.5 | 43.7 | 5.1 | 4.5  | 100.00 |
| TGR-C/6   | 78.97 | 12.5 | 32.3 | 26.1 | 4.5 | 24.6 | 100.00 |
| TGR-C/5   | 78.74 | 10.5 | 42.8 | 29.9 | 5.3 | 11.4 | 100.00 |
| TGR-C/4b  | 78.57 | 7.6  | 29.5 | 38.3 | 5.4 | 19.2 | 100.00 |
| TAT/12b   | 78.47 | 12.2 | 29.1 | 33.0 | 3.9 | 21.9 | 100.00 |
| TGR-C/4a  | 77.87 | 12.2 | 37.7 | 30.5 | 3.8 | 15.9 | 100.00 |
| TGR-C/3A  | 77.48 | 6.8  | 19.1 | 16.1 | 2.2 | 55.9 | 100.00 |
| TGR-C/3b  | 76.80 | 12.1 | 44.6 | 34.0 | 5.5 | 3.9  | 100.00 |
| TGR-C/2   | 75.47 | 9.6  | 40.5 | 31.6 | 5.2 | 13.0 | 100.00 |
| TGR-C/1   | 75.13 | 9.6  | 30.5 | 31.3 | 4.8 | 23.8 | 100.00 |
| SHG-D/26b | 73.05 | 6.4  | 22.5 | 28.0 | 3.1 | 40.0 | 100.00 |
| SHG-D/25  | 72.32 | 7.7  | 29.5 | 35.4 | 4.0 | 23.5 | 100.00 |
| SHG-D/24  | 71.98 | 5.9  | 36.7 | 39.1 | 5.6 | 12.7 | 100.00 |
| SHG-D/23j | 71.85 | 5.9  | 24.5 | 28.1 | 4.2 | 37.3 | 100.00 |
| SHG-D/23i | 71.38 | 5.3  | 23.7 | 24.9 | 3.9 | 42.2 | 100.00 |
| SHG-D/23h | 70.91 | 6.2  | 27.0 | 24.7 | 4.2 | 37.9 | 100.00 |
| SHG-D/23f | 69.97 | 4.9  | 25.1 | 33.8 | 4.0 | 32.2 | 100.00 |
| TAT/11    | 69.86 | 10.1 | 23.2 | 29.2 | 3.4 | 34.1 | 100.00 |
| TAT/10    | 69.59 | 12.1 | 33.8 | 38.7 | 4.4 | 11.0 | 100.00 |
| TAT/9     | 69.22 | 13.1 | 30.8 | 31.2 | 3.8 | 21.0 | 100.00 |
| SHG-D/23d | 69.03 | 5.1  | 18.7 | 20.4 | 3.2 | 52.6 | 100.00 |
| TAT/8b    | 68.66 | 12.4 | 37.7 | 42.9 | 4.8 | 2.3  | 100.00 |
| SHG-D/23b | 68.09 | 5.7  | 17.5 | 25.2 | 2.5 | 49.1 | 100.00 |
| TAT/7b    | 67.99 | 12.9 | 36.9 | 37.8 | 4.5 | 7.9  | 100.00 |
| SHG-D/23a | 67.62 | 7.6  | 38.7 | 42.6 | 5.1 | 6.0  | 100.00 |
| TAT/6b    | 67.24 | 11.5 | 25.4 | 30.1 | 3.5 | 29.5 | 100.00 |
| SHG-D/22  | 67.05 | 4.7  | 16.0 | 14.7 | 1.5 | 63.1 | 100.00 |
| TAT/5     | 66.77 | 10.7 | 40.8 | 32.9 | 5.3 | 10.2 | 100.00 |
| SHG-D/21  | 66.70 | 7.3  | 39.6 | 44.2 | 6.0 | 2.9  | 100.00 |
| TAT/4a    | 66.29 | 8.2  | 35.7 | 31.5 | 5.8 | 18.9 | 100.00 |

|            |       |      |      |      |     |      |        |
|------------|-------|------|------|------|-----|------|--------|
| SHG-D/20a  | 65.83 | 6.3  | 26.6 | 25.3 | 3.0 | 38.8 | 100.00 |
| TAT/3b     | 65.79 | 10.1 | 46.6 | 34.0 | 4.5 | 4.9  | 100.00 |
| SHG-D/19   | 65.42 | 9.0  | 34.3 | 44.5 | 5.7 | 6.5  | 100.00 |
| SHG-D/18   | 65.11 | 5.6  | 23.7 | 23.1 | 2.8 | 44.8 | 100.00 |
| TAT/2      | 65.08 | 10.6 | 39.5 | 30.6 | 5.4 | 13.8 | 100.00 |
| SHG-D/17   | 64.93 | 7.8  | 39.4 | 44.8 | 5.9 | 2.0  | 100.00 |
| TAT/1b     | 64.47 | 9.6  | 31.5 | 32.3 | 4.8 | 21.8 | 100.00 |
| SHG-D/16b  | 64.30 | 8.6  | 26.7 | 27.8 | 3.1 | 33.7 | 100.00 |
| SHG-D/15   | 63.26 | 9.5  | 34.5 | 46.5 | 5.7 | 3.8  | 100.00 |
| SHG-D/14b  | 62.73 | 7.4  | 20.4 | 31.0 | 2.9 | 38.3 | 100.00 |
| SHG-D/13   | 61.98 | 12.7 | 30.3 | 48.3 | 4.1 | 4.6  | 100.00 |
| SHG-D/12   | 60.80 | 10.5 | 33.3 | 50.2 | 4.3 | 1.6  | 100.00 |
| SHG-D/11b  | 58.45 | 7.6  | 36.6 | 47.0 | 7.1 | 1.7  | 100.00 |
| SHG-D/10   | 57.28 | 9.8  | 37.7 | 41.6 | 9.0 | 1.8  | 100.00 |
| SHG-D/9d   | 57.23 | 9.2  | 39.4 | 44.4 | 6.1 | 1.0  | 100.00 |
| SHG-D/9c   | 56.53 | 8.6  | 40.5 | 43.5 | 6.3 | 1.2  | 100.00 |
| SHG-D/9b   | 55.83 | 10.3 | 39.7 | 43.6 | 5.5 | 0.9  | 100.00 |
| SHG-D/9a   | 55.13 | 9.6  | 32.5 | 52.6 | 3.5 | 1.8  | 100.00 |
| SHG-D/8    | 54.35 | 6.7  | 45.9 | 39.3 | 6.7 | 1.4  | 100.00 |
| SHG-D/7b   | 54.18 | 10.0 | 42.8 | 39.9 | 5.7 | 1.7  | 100.00 |
| SHG-D/6    | 51.43 | 2.8  | 12.5 | 13.8 | 1.9 | 69.0 | 100.00 |
| SHG-D/5    | 50.18 | 7.7  | 45.8 | 37.8 | 6.9 | 1.7  | 100.00 |
| SHG-D/4    | 49.35 | 10.2 | 47.5 | 35.0 | 7.1 | 1.4  | 101.00 |
| SHG-D/3a   | 47.55 | 9.8  | 40.8 | 42.4 | 5.6 | 1.4  | 100.00 |
| SHG-D/2    | 46.68 | 7.7  | 33.6 | 27.6 | 4.3 | 26.8 | 100.00 |
| SHG-D/1    | 45.76 | 12.0 | 41.3 | 40.0 | 5.7 | 1.1  | 100.00 |
| TGR-AB/35  | 40.46 | 11.9 | 37.5 | 40.4 | 5.6 | 4.6  | 100.00 |
| TGR-AB/34b | 39.83 | 9.4  | 39.4 | 44.1 | 5.7 | 1.3  | 100.00 |
| TGR-AB/33b | 38.36 | 8.4  | 29.0 | 31.6 | 4.5 | 26.5 | 100.00 |
| TGR-AB/32l | 37.63 | 6.7  | 34.0 | 33.5 | 4.6 | 21.1 | 100.00 |
| TGR-AB/32j | 35.70 | 9.7  | 38.0 | 31.5 | 4.5 | 16.2 | 100.00 |
| TGR-AB/32i | 34.73 | 9.4  | 36.2 | 36.1 | 5.3 | 12.9 | 100.00 |
| TGR-AB/32h | 33.76 | 8.2  | 32.7 | 31.6 | 4.4 | 23.2 | 100.00 |
| TGR-AB/32f | 31.83 | 7.5  | 34.2 | 34.5 | 4.0 | 19.8 | 100.00 |
| TGR-AB/32d | 29.90 | 9.4  | 38.2 | 29.4 | 4.5 | 18.5 | 100.00 |
| TGR-AB/32a | 27.00 | 8.7  | 38.0 | 35.9 | 4.0 | 13.5 | 100.00 |
| TGR-AB/31  | 25.30 | 10.9 | 33.9 | 46.7 | 6.8 | 1.7  | 100.00 |
| TGR-AB/13  | 8.15  | 8.7  | 45.6 | 40.7 | 3.4 | 1.6  | 100.00 |
| TGR-AB/12  | 7.98  | 9.8  | 37.0 | 41.8 | 9.5 | 2.0  | 100.00 |
| TGR-AB/11a | 6.82  | 7.1  | 39.4 | 50.3 | 2.4 | 0.8  | 100.00 |
| TGR-AB/9   | 3.46  | 13.2 | 33.2 | 43.2 | 9.8 | 0.6  | 100.00 |

32 **Table S2a:** Major element composition of the sediments from the Tsagaan Ovoo Fm., Hsanda  
 33 Gol Fm. and Loh Fm. (Valley of Lakes, Mongolia) determined by XRF and TIC analysis.

| Sample ID      | Position<br>(m) | SiO2<br>(wt.%) | Al2O3<br>(wt.%) | Fe2O3<br>(wt.%) | MnO<br>(wt.%) | MgO<br>(wt.%) | CaO<br>(wt.%) | Na2O<br>(wt.%) | K2O<br>(wt.%) | TiO2<br>(wt.%) | P2O5<br>(wt.%) | LOI<br>(wt.%) | SUM<br>(wt.%) | CaO*<br>(wt%) |
|----------------|-----------------|----------------|-----------------|-----------------|---------------|---------------|---------------|----------------|---------------|----------------|----------------|---------------|---------------|---------------|
| HTE/15         | 110.13          | 61.2           | 16.1            | 6.0             | 0.1           | 2.6           | 1.1           | 0.5            | 3.2           | 0.8            | 0.3            | 8.2           | 100.0         | 0.25          |
| HTE/14         | 109.78          | 61.0           | 16.0            | 6.3             | 0.2           | 2.6           | 1.1           | 0.4            | 3.1           | 0.8            | 0.2            | 8.2           | 100.0         | 0.31          |
| HTE/13b        | 108.98          | 61.3           | 16.2            | 6.2             | 0.1           | 2.9           | 1.1           | 0.3            | 3.1           | 0.8            | 0.2            | 7.8           | 100.0         | 0.23          |
| HTE/12         | 107.65          | 27.7           | 7.0             | 2.7             | 0.1           | 1.5           | 30.3          | 0.3            | 1.3           | 0.3            | 0.1            | 28.6          | 100.0         | 0.56          |
| HTE/11b        | 105.78          | 25.5           | 6.6             | 2.6             | 0.1           | 1.4           | 32.2          | 0.2            | 1.3           | 0.3            | 0.5            | 29.2          | 100.0         | 0.58          |
| HTE/11a        | 104.98          | 49.6           | 11.8            | 7.0             | 0.1           | 2.0           | 12.4          | 0.2            | 2.1           | 0.6            | 0.1            | 14.1          | 100.0         | 0.36          |
| HTE/9b         | 101.38          | 40.4           | 10.1            | 4.6             | 2.5           | 1.8           | 18.2          | 0.5            | 1.9           | 0.5            | 0.1            | 19.5          | 100.0         | 0.39          |
| HTE/9a         | 100.97          | 58.3           | 14.8            | 6.1             | 0.1           | 2.1           | 3.7           | 0.3            | 2.7           | 0.8            | 0.1            | 11.0          | 100.0         | 0.55          |
| HTE/8          | 100.40          | 66.6           | 11.9            | 3.9             | 0.1           | 1.2           | 4.0           | 0.8            | 3.5           | 0.6            | 0.1            | 7.2           | 100.0         | 0.38          |
| HTE/7b         | 100.00          | 32.4           | 8.1             | 3.0             | 0.3           | 1.4           | 26.7          | 0.3            | 1.5           | 0.4            | 0.1            | 25.9          | 100.0         | 0.18          |
| HTE/7a         | 98.73           | 61.7           | 15.5            | 6.1             | 0.1           | 2.1           | 3.1           | 0.4            | 2.8           | 0.8            | 0.1            | 7.5           | 100.0         | 0.55          |
| HTE/6          | 97.90           | 54.5           | 13.1            | 5.3             | 0.1           | 1.8           | 8.5           | 0.3            | 2.4           | 0.7            | 0.4            | 13.0          | 100.0         | 0.30          |
| HTE/5a         | 96.83           | 61.7           | 16.1            | 6.3             | 0.1           | 1.8           | 1.1           | 0.3            | 2.8           | 0.8            | 0.1            | 8.9           | 100.0         | 0.45          |
| HTE/4b         | 94.90           | 60.6           | 16.3            | 6.3             | 0.1           | 2.1           | 1.4           | 0.4            | 2.9           | 0.8            | 0.1            | 9.2           | 100.0         | 0.52          |
| HTE/3a         | 94.20           | 50.6           | 13.4            | 5.2             | 0.4           | 1.7           | 10.7          | 0.2            | 2.4           | 0.7            | 0.3            | 14.4          | 100.0         | 0.45          |
| TGR-C/19b      | 93.36           | 47.0           | 12.6            | 5.2             | 0.2           | 2.1           | 14.3          | 0.6            | 2.3           | 0.6            | 0.2            | 15.0          | 100.0         | 0.26          |
| TGR-C/19a      | 92.49           | 40.2           | 10.6            | 4.3             | 0.3           | 1.7           | 19.4          | 0.5            | 1.9           | 0.5            | 0.1            | 20.6          | 100.0         | 0.53          |
| TGR-C/18       | 91.84           | 45.2           | 11.8            | 4.8             | 0.2           | 1.8           | 15.1          | 0.6            | 2.1           | 0.6            | 0.2            | 17.7          | 100.0         | 0.18          |
| TGR-C/17a      | 91.18           | 50.8           | 12.9            | 5.2             | 0.2           | 1.8           | 10.9          | 0.5            | 2.2           | 0.7            | 0.1            | 14.9          | 100.0         | 0.21          |
| TGR-C/16b      | 90.49           | 62.1           | 15.7            | 6.3             | 0.1           | 1.9           | 1.0           | 0.6            | 2.5           | 0.8            | 0.0            | 9.0           | 100.0         | 0.54          |
| TGR-C/15       | 89.24           | 59.3           | 15.4            | 6.2             | 0.1           | 1.8           | 2.7           | 0.5            | 2.4           | 0.8            | 0.0            | 10.8          | 100.0         | 0.33          |
| TGR-C/14b trav | 88.49           | 19.9           | 5.4             | 2.0             | 0.1           | 0.9           | 36.6          | 0.0            | 0.8           | 0.3            | 0.1            | 33.9          | 100.0         | 0.29          |
| TGR-C/14b      | 87.96           | 32.4           | 8.6             | 3.4             | 0.1           | 1.0           | 26.8          | 0.4            | 1.2           | 0.4            | 0.1            | 25.5          | 100.0         | 0.42          |
| TGR-C/13d      | 86.91           | 60.9           | 17.0            | 6.8             | 0.0           | 1.6           | 0.9           | 0.5            | 2.7           | 0.8            | 0.1            | 8.7           | 100.0         | 0.51          |
| TGR-C/13b      | 85.86           | 58.4           | 15.8            | 6.3             | 0.1           | 2.3           | 1.5           | 1.9            | 3.3           | 0.8            | 0.1            | 9.5           | 100.0         | 0.36          |
| TGR-C/12       | 84.77           | 46.1           | 12.3            | 4.8             | 0.1           | 2.1           | 12.9          | 1.7            | 2.6           | 0.6            | 0.1            | 16.7          | 100.0         | 0.38          |
| TGR-C/11b      | 84.69           | 60.4           | 16.6            | 6.5             | 0.2           | 1.7           | 1.5           | 0.9            | 2.8           | 0.8            | 0.1            | 8.6           | 100.0         | 0.19          |
| TGR-C/11a      | 84.32           | 41.4           | 11.0            | 4.3             | 0.1           | 1.9           | 17.4          | 1.5            | 2.3           | 0.5            | 0.1            | 19.4          | 100.0         | 0.42          |
| TGR-C/10b      | 84.14           | 16.8           | 4.4             | 1.7             | 0.1           | 1.0           | 38.7          | 0.5            | 0.8           | 0.2            | 0.1            | 35.8          | 100.0         | 0.40          |
| TGR-C/10a      | 83.24           | 52.2           | 13.9            | 5.5             | 0.1           | 2.3           | 7.3           | 2.0            | 2.9           | 0.7            | 0.1            | 13.1          | 100.0         | 0.09          |
| TGR-C/9        | 82.66           | 45.5           | 12.1            | 4.8             | 0.1           | 2.1           | 12.9          | 2.2            | 2.6           | 0.6            | 0.2            | 16.9          | 100.0         | 0.32          |
| TGR-C/8b       | 82.39           | 59.0           | 15.4            | 6.1             | 0.1           | 2.7           | 1.6           | 2.1            | 3.4           | 0.8            | 0.1            | 8.8           | 100.0         | 0.37          |
| TGR-C/8a       | 81.12           | 47.3           | 12.6            | 5.0             | 0.0           | 2.0           | 13.3          | 0.7            | 2.5           | 0.6            | 0.1            | 15.8          | 100.0         | 0.56          |
| TGR-C/7b       | 80.01           | 55.0           | 14.4            | 5.7             | 0.1           | 2.4           | 5.2           | 2.2            | 3.2           | 0.7            | 0.2            | 10.9          | 100.0         | 0.20          |
| TGR-C/6        | 78.97           | 43.8           | 11.4            | 4.5             | 0.1           | 2.1           | 14.7          | 2.1            | 2.5           | 0.6            | 0.3            | 17.9          | 100.0         | 0.21          |
| TGR-C/5        | 78.74           | 54.3           | 14.1            | 5.6             | 0.2           | 2.3           | 6.2           | 2.0            | 3.4           | 0.7            | 0.5            | 10.6          | 100.0         | 0.19          |
| TGR-C/4b       | 78.57           | 49.2           | 13.5            | 5.4             | 0.2           | 2.0           | 10.7          | 0.9            | 2.7           | 0.7            | 0.1            | 14.5          | 100.0         | 0.10          |
| TGR-C/4a       | 77.87           | 50.2           | 12.8            | 5.0             | 0.1           | 2.2           | 10.1          | 2.1            | 3.1           | 0.6            | 0.1            | 13.7          | 100.0         | 0.15          |
| TGR-C/3A       | 77.48           | 24.8           | 6.8             | 2.7             | 0.0           | 1.2           | 32.4          | 0.4            | 1.4           | 0.3            | 0.1            | 29.9          | 100.0         | 0.32          |
| TGR-C/3b       | 76.80           | 59.0           | 14.9            | 5.9             | 0.1           | 2.5           | 2.3           | 2.2            | 3.8           | 0.7            | 0.1            | 8.6           | 100.0         | 0.44          |
| TGR-C/2        | 75.47           | 53.7           | 13.7            | 5.4             | 0.1           | 2.2           | 7.4           | 1.7            | 3.4           | 0.7            | 0.1            | 11.7          | 100.0         | 0.33          |
| TGR-C/1        | 75.13           | 47.0           | 11.9            | 4.8             | 0.1           | 2.2           | 13.2          | 1.4            | 2.6           | 0.6            | 0.1            | 16.0          | 100.0         | 0.24          |
| SHG-D/26b      | 73.05           | 36.5           | 9.4             | 3.7             | 0.3           | 1.6           | 23.5          | 0.4            | 1.8           | 0.5            | 0.0            | 22.3          | 100.0         | 0.55          |
| SHG-D/25       | 72.32           | 47.9           | 12.3            | 4.9             | 0.1           | 1.9           | 14.2          | 0.6            | 2.5           | 0.6            | 0.1            | 14.9          | 100.0         | 0.36          |
| SHG-D/24       | 71.98           | 55.2           | 14.3            | 5.7             | 0.1           | 2.2           | 7.0           | 0.7            | 2.8           | 0.7            | 0.1            | 11.2          | 100.0         | 0.22          |
| SHG-D/23j      | 71.85           | 39.7           | 10.3            | 4.0             | 0.1           | 1.7           | 20.9          | 0.5            | 2.1           | 0.5            | 0.1            | 20.1          | 100.0         | 0.25          |
| SHG-D/23i      | 71.38           | 35.0           | 9.1             | 3.6             | 0.2           | 1.5           | 24.7          | 0.4            | 1.8           | 0.4            | 0.1            | 23.2          | 100.0         | 0.45          |

|            |       |      |      |      |     |     |      |     |     |     |     |      |       |      |
|------------|-------|------|------|------|-----|-----|------|-----|-----|-----|-----|------|-------|------|
| SHG-D/23h  | 70.91 | 38.5 | 10.0 | 4.0  | 0.1 | 1.7 | 21.8 | 0.5 | 2.0 | 0.5 | 0.1 | 20.8 | 100.0 | 0.11 |
| SHG-D/23f  | 69.97 | 43.2 | 11.3 | 4.4  | 0.1 | 1.6 | 18.0 | 0.6 | 2.3 | 0.6 | 0.1 | 17.7 | 100.0 | 0.17 |
| SHG-D/23d  | 69.03 | 26.9 | 7.0  | 2.7  | 0.2 | 1.2 | 30.7 | 0.6 | 1.5 | 0.3 | 0.1 | 28.8 | 100.0 | 0.57 |
| SHG-D/23b  | 68.09 | 31.6 | 8.0  | 3.1  | 0.2 | 1.4 | 27.5 | 0.6 | 1.6 | 0.4 | 0.1 | 25.6 | 100.0 | 0.54 |
| SHG-D/23a  | 67.62 | 60.2 | 15.6 | 6.2  | 0.1 | 2.3 | 3.3  | 0.9 | 3.1 | 0.8 | 0.1 | 7.4  | 100.0 | 0.37 |
| SHG-D/22   | 67.05 | 19.2 | 4.9  | 1.9  | 0.1 | 1.2 | 37.0 | 0.3 | 1.0 | 0.2 | 0.1 | 34.0 | 100.0 | 0.29 |
| SHG-D/21   | 66.70 | 61.2 | 15.9 | 6.2  | 0.1 | 2.4 | 1.5  | 0.9 | 3.2 | 0.8 | 0.1 | 7.7  | 100.0 | 0.26 |
| SHG-D/20a  | 65.83 | 37.5 | 9.6  | 3.8  | 0.2 | 1.6 | 22.2 | 0.6 | 2.0 | 0.5 | 0.2 | 21.8 | 100.0 | 0.34 |
| SHG-D/19   | 65.42 | 59.3 | 15.1 | 5.9  | 0.2 | 2.4 | 2.9  | 1.1 | 3.2 | 0.8 | 0.1 | 9.0  | 100.0 | 0.43 |
| SHG-D/18   | 65.11 | 35.6 | 9.0  | 3.5  | 0.2 | 1.6 | 24.0 | 0.6 | 1.9 | 0.4 | 0.1 | 23.1 | 100.0 | 0.51 |
| SHG-D/17   | 64.93 | 61.5 | 15.6 | 6.1  | 0.1 | 2.4 | 1.6  | 1.0 | 3.3 | 0.8 | 0.1 | 7.6  | 100.0 | 0.30 |
| SHG-D/16b  | 64.30 | 41.1 | 10.2 | 4.0  | 0.2 | 1.7 | 20.0 | 0.8 | 2.2 | 0.5 | 0.1 | 19.2 | 100.0 | 0.18 |
| SHG-D/15   | 63.26 | 62.3 | 15.3 | 5.9  | 0.1 | 2.3 | 2.0  | 1.2 | 3.2 | 0.8 | 0.1 | 6.8  | 100.0 | 0.42 |
| SHG-D/14b  | 62.73 | 40.2 | 9.6  | 3.6  | 0.2 | 1.5 | 20.9 | 0.8 | 2.0 | 0.5 | 0.1 | 20.6 | 100.0 | 0.53 |
| SHG-D/13   | 61.98 | 64.0 | 14.2 | 5.1  | 0.1 | 2.0 | 2.0  | 1.6 | 2.8 | 0.8 | 0.2 | 7.3  | 100.0 | 0.18 |
| SHG-D/12   | 60.80 | 68.8 | 14.3 | 4.4  | 0.1 | 1.7 | 1.1  | 1.8 | 2.9 | 0.8 | 0.1 | 4.1  | 100.0 | 0.09 |
| SHG-D/11b  | 58.45 | 61.6 | 16.8 | 7.3  | 0.1 | 2.3 | 0.8  | 0.7 | 3.0 | 0.8 | 0.1 | 6.6  | 100.0 | 0.28 |
| SHG-D/10   | 57.28 | 57.7 | 16.9 | 10.2 | 0.3 | 2.5 | 0.7  | 0.6 | 3.2 | 0.8 | 0.1 | 6.9  | 100.0 | 0.44 |
| SHG-D/9d   | 57.23 | 61.0 | 16.5 | 6.3  | 1.4 | 2.4 | 0.8  | 0.8 | 3.2 | 0.8 | 0.1 | 6.7  | 100.0 | 0.60 |
| SHG-D/9c   | 56.53 | 62.7 | 16.6 | 6.5  | 0.1 | 2.4 | 0.6  | 0.8 | 3.4 | 0.8 | 0.1 | 5.9  | 100.0 | 0.27 |
| SHG-D/9b   | 55.83 | 66.0 | 15.0 | 5.7  | 0.1 | 2.3 | 0.5  | 1.5 | 3.2 | 0.8 | 0.1 | 4.8  | 100.0 | 0.21 |
| SHG-D/9a   | 55.13 | 69.1 | 12.7 | 4.4  | 0.0 | 2.1 | 0.9  | 1.8 | 2.6 | 0.8 | 0.0 | 5.6  | 100.0 | 0.56 |
| SHG-D/8    | 54.35 | 60.3 | 17.7 | 7.1  | 0.1 | 2.9 | 0.6  | 0.6 | 3.7 | 0.8 | 0.0 | 6.2  | 100.0 | 0.34 |
| SHG-D/7b   | 54.18 | 60.4 | 15.6 | 6.4  | 0.1 | 3.1 | 0.9  | 1.2 | 3.5 | 0.8 | 0.1 | 7.9  | 100.0 | 0.33 |
| SHG-D/6    | 51.43 | 18.4 | 5.2  | 2.1  | 0.1 | 1.1 | 37.4 | 0.2 | 1.1 | 0.2 | 0.6 | 33.5 | 100.0 | 0.50 |
| SHG-D/5    | 50.18 | 59.4 | 17.3 | 7.3  | 0.1 | 2.8 | 0.8  | 0.8 | 3.7 | 0.8 | 0.1 | 6.9  | 100.0 | 0.26 |
| SHG-D/4    | 49.35 | 58.7 | 17.0 | 7.5  | 0.1 | 3.0 | 0.6  | 1.0 | 3.9 | 0.7 | 0.1 | 7.3  | 100.0 | 0.32 |
| SHG-D/3a   | 47.55 | 62.5 | 16.2 | 6.6  | 0.1 | 2.8 | 0.3  | 1.2 | 3.8 | 0.8 | 0.1 | 5.5  | 100.0 | 0.39 |
| SHG-D/2    | 46.68 | 46.3 | 12.5 | 5.5  | 0.3 | 2.2 | 13.8 | 0.8 | 3.0 | 0.6 | 0.2 | 14.8 | 100.0 | 0.52 |
| SHG-D/1    | 45.76 | 61.6 | 15.3 | 6.0  | 0.1 | 3.3 | 0.6  | 2.1 | 3.5 | 0.7 | 0.3 | 6.6  | 100.0 | 0.11 |
| TGR-AB/35  | 40.46 | 61.6 | 13.4 | 6.7  | 0.0 | 2.8 | 1.9  | 1.5 | 3.0 | 0.6 | 0.5 | 7.9  | 100.0 | 0.58 |
| TGR-AB/34b | 39.83 | 64.3 | 15.4 | 6.1  | 0.1 | 3.6 | 0.7  | 1.0 | 3.6 | 0.8 | 0.1 | 4.4  | 100.0 | 0.30 |
| TGR-AB/33b | 38.36 | 45.5 | 11.5 | 4.5  | 0.1 | 2.4 | 16.3 | 0.8 | 2.7 | 0.6 | 0.1 | 15.5 | 100.0 | 0.22 |
| TGR-AB/32l | 37.63 | 52.4 | 13.5 | 5.3  | 0.1 | 2.7 | 10.2 | 1.0 | 3.2 | 0.7 | 0.2 | 10.8 | 100.0 | 0.16 |
| TGR-AB/32j | 35.70 | 52.4 | 13.5 | 5.3  | 0.1 | 2.7 | 10.2 | 1.0 | 3.2 | 0.7 | 0.2 | 10.8 | 100.0 | 0.31 |
| TGR-AB/32i | 34.73 | 56.7 | 14.1 | 5.6  | 0.1 | 2.4 | 6.6  | 1.0 | 3.4 | 0.7 | 0.1 | 9.2  | 100.0 | 0.11 |
| TGR-AB/32h | 33.76 | 48.8 | 12.3 | 4.8  | 0.1 | 2.6 | 13.2 | 0.8 | 2.9 | 0.6 | 0.1 | 13.9 | 100.0 | 0.30 |
| TGR-AB/32f | 31.83 | 49.5 | 12.5 | 4.9  | 0.2 | 2.6 | 12.2 | 0.9 | 2.9 | 0.6 | 0.1 | 13.8 | 100.0 | 0.35 |
| TGR-AB/32d | 29.90 | 49.9 | 12.6 | 4.7  | 0.4 | 2.3 | 11.3 | 1.4 | 3.2 | 0.6 | 0.2 | 13.4 | 100.0 | 0.43 |
| TGR-AB/32a | 27.00 | 55.3 | 13.9 | 5.2  | 0.2 | 2.3 | 8.1  | 0.9 | 3.2 | 0.7 | 0.2 | 10.0 | 100.0 | 0.52 |
| TGR-AB/31  | 25.30 | 64.7 | 14.9 | 7.0  | 0.1 | 2.0 | 1.0  | 1.6 | 3.1 | 0.8 | 0.1 | 4.7  | 100.0 | 0.48 |
| TGR-AB/13  | 8.15  | 66.4 | 16.5 | 4.7  | 0.0 | 1.3 | 0.9  | 1.3 | 3.4 | 0.8 | 0.1 | 4.6  | 100.0 | 0.56 |
| TGR-AB/12  | 7.98  | 56.7 | 16.5 | 10.6 | 1.8 | 1.7 | 0.9  | 0.8 | 2.9 | 0.8 | 0.1 | 7.2  | 100.0 | 0.54 |
| TGR-AB/11a | 6.82  | 70.8 | 13.7 | 3.8  | 0.0 | 1.4 | 0.5  | 1.5 | 3.7 | 0.5 | 0.0 | 4.1  | 100.0 | 0.21 |
| TGR-AB/9   | 3.46  | 59.3 | 16.8 | 11.0 | 0.1 | 1.2 | 0.3  | 1.6 | 3.0 | 0.7 | 0.2 | 5.8  | 100.0 | 0.31 |

35 **Table S2b:** Minor and trace element composition (in mg/kg) of the sediments from the Tsagaan  
36 Ovoo Fm., Hsanda Gol Fm. and Loh Fm. (Valley of Lakes, Mongolia) determined by XRF  
37 analysis.

| Sample ID      | Ba   | Ce  | Co  | Cr  | Cu  | Ga  | Hf  | La  | Nb  | Ni  | Pb   | Rb  | Sc   | Sr  | Th | U   | V   | Y  | Zn  | Zr  |
|----------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|------|-----|----|-----|-----|----|-----|-----|
| HTE/15         | 433  | 80  | <20 | 74  | 33  | 20  | <15 | 46  | <20 | 50  | 21   | 128 | 20   | 118 | 20 | <20 | 94  | 31 | 102 | 170 |
| HTE/14         | 520  | 75  | <20 | 72  | 38  | 24  | <15 | 44  | <20 | 50  | 32   | 126 | 20   | 122 | 20 | <20 | 108 | 29 | 100 | 189 |
| HTE/13b        | 469  | 89  | <20 | 75  | 33  | 21  | <15 | 44  | 20  | 50  | 20   | 126 | 20   | 116 | 20 | <20 | 108 | 34 | 100 | 160 |
| HTE/12         | 207  | 55  | <20 | 41  | <20 | 10  | <15 | 86  | <20 | 23  | 19.6 | 56  | 25.1 | 239 | 20 | <20 | 59  | 16 | 42  | 88  |
| HTE/11b        | 158  | 56  | <20 | 49  | <20 | <10 | <15 | 72  | <20 | 29  | <20  | 57  | 20   | 164 | 20 | <20 | 33  | 27 | 42  | 70  |
| HTE/11a        | 354  | 88  | <20 | 52  | 34  | 13  | <15 | 48  | <20 | 32  | 31   | 97  | 20   | 211 | 20 | <20 | 98  | 34 | 73  | 124 |
| HTE/9b         | 1468 | 53  | <20 | 59  | 34  | 12  | <15 | 39  | <20 | 27  | <20  | 81  | 20   | 238 | 20 | <20 | 123 | 18 | 68  | 125 |
| HTE/9a         | 398  | 82  | 20  | 74  | 32  | 19  | <15 | 46  | <20 | 37  | 34   | 124 | 20   | 141 | 20 | <20 | 103 | 22 | 83  | 170 |
| HTE/8          | 606  | 88  | <20 | 49  | 24  | 13  | <15 | 64  | <20 | 27  | 36   | 135 | 20   | 184 | 20 | <20 | 71  | 17 | 53  | 146 |
| HTE/7b         | 560  | 30  | <20 | 51  | <20 | 11  | <15 | 63  | <20 | 29  | <20  | 68  | 27   | 212 | 20 | <20 | 72  | 19 | 46  | 90  |
| HTE/7a         | 391  | 83  | 24  | 83  | 44  | 20  | <15 | 44  | <20 | 42  | 26.5 | 126 | 21.1 | 142 | 20 | <20 | 105 | 20 | 88  | 167 |
| HTE/6          | 352  | 126 | <20 | 63  | 26  | 20  | <15 | 44  | <20 | 33  | 30   | 110 | 20   | 177 | 20 | <20 | 93  | 31 | 79  | 175 |
| HTE/5a         | 369  | 88  | <20 | 87  | 31  | 21  | <15 | 43  | <20 | 36  | 23   | 133 | 20   | 108 | 20 | <20 | 100 | 23 | 97  | 187 |
| HTE/4b         | 384  | 54  | <20 | 78  | 33  | 24  | <15 | 42  | <20 | 38  | 28   | 139 | 20   | 109 | 20 | <20 | 118 | 19 | 97  | 160 |
| HTE/3a         | 600  | 79  | <20 | 72  | 29  | 20  | <15 | 30  | <20 | 38  | 23   | 111 | 20   | 152 | 20 | <20 | 96  | 22 | 81  | 144 |
| TGR-C/19b      | 332  | 77  | <20 | 57  | 30  | 16  | <15 | 34  | <20 | 39  | 25   | 102 | 25   | 117 | 20 | <20 | 90  | 31 | 71  | 152 |
| TGR-C/19a      | 503  | 59  | <20 | 54  | 27  | 15  | <15 | 30  | <20 | 29  | <20  | 85  | 20   | 134 | 20 | <20 | 78  | 26 | 58  | 141 |
| TGR-C/18       | 338  | 49  | <20 | 48  | 25  | 17  | <15 | 32  | <20 | 30  | <20  | 95  | 20   | 152 | 20 | <20 | 77  | 28 | 62  | 150 |
| TGR-C/17a      | 407  | 91  | <20 | 52  | 29  | 17  | <15 | 30  | <20 | 33  | 35   | 106 | 20   | 144 | 20 | <20 | 70  | 23 | 67  | 185 |
| TGR-C/16b      | 379  | 81  | <20 | 81  | 37  | 23  | <15 | 51  | <20 | 34  | 31   | 129 | 20   | 119 | 20 | <20 | 113 | 24 | 77  | 192 |
| TGR-C/15       | 355  | 51  | <20 | 74  | 26  | 21  | <15 | 32  | <20 | 29  | 31   | 124 | 20   | 120 | 20 | <20 | 106 | 23 | 88  | 190 |
| TGR-C/14b trav | 240  | 51  | <20 | 36  | <20 | <10 | <15 | 101 | 22  | <20 | <20  | 48  | 26   | 214 | 20 | <20 | 35  | 54 | 32  | 56  |
| TGR-C/14b      | 263  | 71  | <20 | 48  | 27  | <10 | <15 | 80  | <20 | 27  | 26   | 72  | 30   | 167 | 20 | <20 | 69  | 17 | 51  | 115 |
| TGR-C/13d      | 329  | 82  | <20 | 90  | 38  | 22  | <15 | 55  | <20 | 33  | 31   | 140 | 20   | 95  | 20 | <20 | 120 | 21 | 95  | 180 |
| TGR-C/13b      | 479  | 88  | <20 | 68  | 41  | 22  | <15 | 68  | <20 | 44  | 31   | 133 | 20   | 149 | 8  | <20 | 109 | 25 | 98  | 161 |
| TGR-C/12       | 341  | 52  | <20 | 53  | 33  | 16  | <15 | 41  | <20 | 29  | 20   | 103 | 20   | 188 | 9  | <20 | 94  | 26 | 75  | 142 |
| TGR-C/11b      | 578  | 76  | 23  | 78  | 37  | 24  | <15 | 61  | <20 | 45  | 26   | 140 | 20   | 108 | 20 | <20 | 118 | 23 | 90  | 184 |
| TGR-C/11a      | 282  | 56  | <20 | 51  | 29  | 12  | <15 | 30  | <20 | 29  | <20  | 91  | 20   | 197 | 10 | <20 | 92  | 21 | 70  | 136 |
| TGR-C/10b      | 204  | 30  | <20 | 42  | <20 | <10 | <15 | 92  | <20 | <20 | <20  | 39  | 29   | 189 | 20 | <20 | 33  | 15 | 29  | 61  |
| TGR-C/10a      | 424  | 93  | <20 | 63  | 38  | 19  | <15 | 30  | <20 | 35  | 32   | 117 | 20   | 177 | 11 | <20 | 104 | 24 | 87  | 172 |
| TGR-C/9        | 356  | 76  | <20 | 48  | 37  | 16  | <15 | 30  | <20 | 27  | 25   | 101 | 20   | 227 | 12 | <20 | 99  | 23 | 78  | 133 |
| TGR-C/8b       | 411  | 74  | <20 | 67  | 44  | 20  | <15 | 35  | <20 | 39  | 25   | 135 | 20   | 193 | 13 | <20 | 116 | 21 | 95  | 170 |
| TGR-C/8a       | 314  | 72  | <20 | 70  | 30  | 18  | <15 | 34  | <20 | 29  | 25   | 109 | 24   | 121 | 20 | <20 | 93  | 23 | 81  | 152 |
| TGR-C/7b       | 380  | 64  | <20 | 70  | 41  | 19  | <15 | 44  | <20 | 40  | 26   | 129 | 20   | 136 | 14 | <20 | 119 | 26 | 92  | 160 |
| TGR-C/6        | 291  | 70  | <20 | 53  | 35  | 14  | <15 | 30  | <20 | 28  | 23   | 98  | 20   | 235 | 15 | <20 | 95  | 29 | 75  | 134 |
| TGR-C/5        | 1119 | 69  | <20 | 59  | 46  | 18  | <15 | 54  | <20 | 49  | 30   | 126 | 20   | 235 | 16 | <20 | 115 | 31 | 98  | 157 |
| TGR-C/4b       | 578  | 72  | 20  | 68  | 36  | 16  | <15 | 30  | <20 | 38  | 37   | 121 | 20   | 127 | 20 | <20 | 103 | 28 | 90  | 171 |
| TGR-C/4a       | 353  | 74  | <20 | 59  | 37  | 18  | <15 | 30  | <20 | 28  | 23   | 116 | 20   | 166 | 17 | <20 | 104 | 21 | 85  | 152 |
| TGR-C/3A       | 171  | 33  | <20 | 49  | <20 | <10 | <15 | 77  | <20 | 20  | 22   | 61  | 20   | 148 | 20 | <20 | 44  | 19 | 46  | 103 |
| TGR-C/3b       | 649  | 75  | <20 | 63  | 49  | 19  | <15 | 30  | <20 | 39  | 27   | 136 | 20   | 140 | 18 | <20 | 125 | 22 | 99  | 175 |
| TGR-C/2        | 347  | 72  | <20 | 67  | 45  | 17  | <15 | 40  | <20 | 32  | 20   | 123 | 20   | 133 | 19 | <20 | 116 | 25 | 89  | 158 |
| TGR-C/1        | 325  | 67  | <20 | 108 | 77  | 16  | <15 | 30  | <20 | 46  | 21   | 103 | 20   | 193 | 20 | <20 | 92  | 22 | 79  | 142 |
| SHG-D/26b      | 547  | 56  | 22  | 45  | 25  | 13  | <15 | 30  | <20 | 35  | 26   | 81  | 20   | 302 | 20 | <20 | 75  | 32 | 59  | 112 |
| SHG-D/25       | 444  | 51  | <20 | 54  | 35  | 14  | <15 | 30  | <20 | 32  | 22   | 104 | 20   | 191 | 20 | <20 | 101 | 25 | 80  | 131 |
| SHG-D/24       | 437  | 60  | <20 | 57  | 42  | 16  | <15 | 30  | <20 | 43  | 29   | 121 | 20   | 197 | 20 | <20 | 113 | 23 | 89  | 167 |
| SHG-D/23j      | 386  | 45  | <20 | 55  | 29  | 12  | <15 | 30  | <20 | 29  | 26   | 87  | 20   | 186 | 20 | <20 | 88  | 24 | 67  | 136 |

|            |      |     |     |     |     |     |     |     |     |     |     |     |    |     |    |     |     |    |     |     |
|------------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|----|-----|-----|----|-----|-----|
| SHG-D/23i  | 395  | 61  | <20 | 58  | 27  | 10  | <15 | 30  | <20 | 28  | <20 | 79  | 20 | 203 | 20 | <20 | 71  | 17 | 59  | 104 |
| SHG-D/23h  | 399  | 46  | <20 | 142 | 22  | 14  | <15 | 30  | <20 | 53  | <20 | 83  | 20 | 214 | 20 | <20 | 85  | 24 | 63  | 105 |
| SHG-D/23f  | 432  | 68  | <20 | 62  | 30  | 14  | <15 | 30  | <20 | 24  | 23  | 95  | 20 | 184 | 20 | <20 | 79  | 25 | 74  | 107 |
| SHG-D/23d  | 338  | 46  | <20 | 54  | <20 | 10  | <15 | 97  | <20 | 28  | <20 | 60  | 20 | 213 | 20 | <20 | 49  | 18 | 50  | 97  |
| SHG-D/23b  | 475  | 44  | <20 | 53  | 27  | <10 | <15 | 66  | <20 | 28  | 22  | 68  | 21 | 180 | 20 | <20 | 71  | 22 | 52  | 96  |
| SHG-D/23a  | 483  | 82  | <20 | 73  | 37  | 18  | <15 | 29  | <20 | 41  | 31  | 134 | 20 | 162 | 20 | <20 | 124 | 23 | 92  | 173 |
| SHG-D/22   | 196  | 33  | <20 | 38  | <20 | <10 | <15 | 80  | <20 | 21  | <20 | 42  | 31 | 247 | 20 | <20 | 31  | 16 | 38  | 77  |
| SHG-D/21   | 484  | 78  | <20 | 93  | 39  | 21  | <15 | 41  | <20 | 50  | 32  | 135 | 20 | 179 | 20 | <20 | 120 | 24 | 99  | 173 |
| SHG-D/20a  | 424  | 55  | <20 | 48  | 24  | 15  | <15 | 30  | <20 | 27  | 23  | 84  | 23 | 152 | 20 | <20 | 72  | 19 | 61  | 109 |
| SHG-D/19   | 652  | 96  | 31  | 68  | 43  | 21  | <15 | 68  | <20 | 44  | 30  | 131 | 20 | 170 | 20 | <20 | 122 | 22 | 96  | 165 |
| SHG-D/18   | 473  | 37  | <20 | 47  | 27  | 12  | <15 | 30  | <20 | 27  | <20 | 79  | 24 | 161 | 20 | <20 | 77  | 19 | 56  | 95  |
| SHG-D/17   | 463  | 64  | <20 | 72  | 37  | 20  | <15 | 45  | <20 | 40  | 31  | 135 | 20 | 152 | 20 | <20 | 114 | 25 | 97  | 184 |
| SHG-D/16b  | 472  | 69  | <20 | 52  | 25  | 13  | <15 | 30  | <20 | 28  | <20 | 90  | 20 | 159 | 20 | <20 | 83  | 21 | 63  | 134 |
| SHG-D/15   | 463  | 88  | <20 | 73  | 31  | 17  | <15 | 55  | <20 | 39  | 32  | 135 | 20 | 191 | 20 | <20 | 112 | 28 | 95  | 174 |
| SHG-D/14b  | 425  | 65  | <20 | 45  | 25  | 13  | <15 | 31  | <20 | 24  | 23  | 86  | 20 | 167 | 20 | <20 | 67  | 29 | 61  | 130 |
| SHG-D/13   | 423  | 86  | <20 | 54  | 34  | 19  | <15 | 74  | 21  | 32  | 28  | 133 | 20 | 210 | 23 | <20 | 89  | 34 | 85  | 205 |
| SHG-D/12   | 475  | 103 | <20 | 55  | 28  | 17  | <15 | 60  | <20 | 25  | 26  | 138 | 20 | 183 | 20 | <20 | 65  | 31 | 76  | 249 |
| SHG-D/11b  | 481  | 101 | 21  | 82  | 40  | 23  | <15 | 39  | 21  | 43  | 30  | 155 | 20 | 264 | 23 | <20 | 149 | 32 | 113 | 156 |
| SHG-D/10   | 636  | 59  | 26  | 88  | 45  | 24  | <15 | 47  | <20 | 46  | 28  | 157 | 20 | 252 | 21 | <20 | 200 | 25 | 119 | 143 |
| SHG-D/9d   | 2439 | 99  | <20 | 68  | 39  | 21  | <15 | 65  | 22  | 72  | 27  | 150 | 20 | 283 | 20 | <20 | 139 | 37 | 107 | 170 |
| SHG-D/9c   | 414  | 81  | <20 | 76  | 32  | 23  | <15 | 53  | <20 | 35  | <20 | 151 | 20 | 173 | 20 | <20 | 109 | 27 | 103 | 176 |
| SHG-D/9b   | 435  | 81  | <20 | 67  | 28  | 22  | <15 | 59  | <20 | 40  | 41  | 134 | 20 | 170 | 20 | <20 | 89  | 30 | 90  | 189 |
| SHG-D/9a   | 332  | 88  | <20 | 60  | 31  | 15  | <15 | 61  | <20 | 31  | <20 | 110 | 20 | 291 | 20 | <20 | 72  | 28 | 69  | 273 |
| SHG-D/8    | 456  | 56  | 22  | 87  | 43  | 22  | <15 | 64  | <20 | 49  | 36  | 159 | 20 | 242 | 20 | <20 | 122 | 27 | 115 | 171 |
| SHG-D/7b   | 444  | 100 | <20 | 69  | 40  | 21  | <15 | 59  | <20 | 49  | 26  | 136 | 20 | 268 | 20 | <20 | 108 | 30 | 102 | 164 |
| SHG-D/6    | 185  | 51  | <20 | 46  | <20 | <10 | <15 | 106 | 26  | <20 | <20 | 49  | 22 | 183 | 20 | <20 | 39  | 65 | 36  | 71  |
| SHG-D/5    | 496  | 71  | <20 | 80  | 38  | 22  | <15 | 49  | <20 | 45  | 37  | 159 | 20 | 216 | 20 | <20 | 120 | 33 | 114 | 133 |
| SHG-D/4    | 503  | 100 | <20 | 76  | 34  | 23  | <15 | 45  | <20 | 43  | <20 | 151 | 20 | 160 | 20 | <20 | 122 | 25 | 109 | 153 |
| SHG-D/3a   | 484  | 68  | <20 | 82  | 38  | 20  | <15 | 30  | <20 | 47  | 20  | 141 | 20 | 169 | 20 | <20 | 109 | 29 | 104 | 184 |
| SHG-D/2    | 693  | 51  | <20 | 71  | 29  | 17  | <15 | 32  | <20 | 40  | 24  | 110 | 20 | 169 | 20 | <20 | 97  | 24 | 84  | 152 |
| SHG-D/1    | 465  | 83  | <20 | 67  | 36  | 19  | <15 | 48  | 20  | 42  | 26  | 133 | 20 | 127 | 20 | <20 | 117 | 35 | 98  | 199 |
| TGR-AB/35  | 492  | 49  | 24  | 75  | 66  | 24  | <15 | 30  | 26  | 72  | 25  | 79  | 20 | 273 | 20 | <20 | 56  | 13 | 63  | 165 |
| TGR-AB/34b | 445  | 70  | 21  | 67  | 72  | 21  | <15 | 44  | <20 | 54  | 31  | 155 | 20 | 137 | 20 | <20 | 85  | 26 | 111 | 171 |
| TGR-AB/33b | 310  | 85  | <20 | 63  | 28  | 14  | <15 | 30  | <20 | 31  | 27  | 117 | 20 | 107 | 20 | <20 | 75  | 24 | 72  | 144 |
| TGR-AB/32i | 380  | 91  | <20 | 65  | 32  | 15  | <15 | 30  | <20 | 34  | 22  | 130 | 20 | 126 | 20 | <20 | 89  | 25 | 89  | 176 |
| TGR-AB/32j | 380  | 91  | <20 | 65  | 32  | 15  | <15 | 30  | <20 | 34  | 22  | 130 | 20 | 126 | 20 | <20 | 89  | 25 | 89  | 176 |
| TGR-AB/32i | 424  | 86  | <20 | 62  | 27  | 18  | <15 | 57  | <20 | 34  | 31  | 135 | 20 | 159 | 20 | <20 | 107 | 28 | 93  | 160 |
| TGR-AB/32h | 286  | 63  | <20 | 61  | 30  | 16  | <15 | 30  | <20 | 30  | <20 | 119 | 22 | 107 | 20 | <20 | 89  | 23 | 79  | 135 |
| TGR-AB/32f | 400  | 68  | <20 | 61  | 32  | 13  | <15 | 49  | <20 | 31  | 24  | 119 | 20 | 152 | 20 | <20 | 85  | 23 | 78  | 173 |
| TGR-AB/32d | 854  | 61  | <20 | 61  | 30  | 16  | <15 | 30  | <20 | 35  | 23  | 125 | 20 | 179 | 20 | <20 | 82  | 28 | 82  | 156 |
| TGR-AB/32a | 532  | 99  | <20 | 61  | 25  | 18  | <15 | 49  | <20 | 32  | 40  | 144 | 20 | 165 | 21 | <20 | 83  | 25 | 84  | 169 |
| TGR-AB/31  | 441  | 93  | <20 | 75  | 32  | 20  | <15 | 53  | <20 | 37  | 25  | 141 | 20 | 186 | 22 | <20 | 115 | 25 | 92  | 270 |
| TGR-AB/13  | 495  | 98  | <20 | 59  | 22  | 21  | <15 | 67  | <20 | <20 | 20  | 159 | 20 | 153 | 24 | <20 | 58  | 28 | 66  | 316 |
| TGR-AB/12  | 4111 | 62  | 46  | 72  | 40  | 23  | <15 | 47  | <20 | 50  | 24  | 151 | 20 | 252 | 31 | <20 | 250 | 27 | 95  | 230 |
| TGR-AB/11a | 481  | 54  | <20 | 32  | <20 | 16  | <15 | 31  | <20 | <20 | 20  | 145 | 20 | 142 | 20 | <20 | 47  | 18 | 51  | 227 |
| TGR-AB/9   | 481  | 62  | 28  | 83  | 46  | 24  | <15 | 30  | <20 | 64  | 37  | 139 | 20 | 123 | 27 | <20 | 160 | 20 | 76  | 274 |



39 **Table S3:** Chemical weathering indices calculated for the sediments from the Tsagaan Ovoo  
 40 Fm., Hsanda Gol Fm. and Loh Fm. (Valley of Lakes, Mongolia) based on XRF and TIC data.

| Sample ID         | Position<br>(m) | CIA | CIW | PIA |
|-------------------|-----------------|-----|-----|-----|
| HTE/15            | 110.13          | 80  | 95  | 94  |
| HTE/14            | 109.78          | 81  | 96  | 95  |
| HTE/13b           | 108.98          | 82  | 97  | 96  |
| HTE/12            | 107.65          | 76  | 89  | 87  |
| HTE/11b           | 105.78          | 76  | 89  | 87  |
| HTE/11a           | 104.98          | 81  | 95  | 94  |
| HTE/9b            | 101.38          | 79  | 92  | 90  |
| HTE/9a            | 100.97          | 80  | 94  | 93  |
| HTE/8             | 100.40          | 72  | 91  | 88  |
| HTE/7b            | 100.00          | 80  | 94  | 93  |
| HTE/7a            | 98.73           | 81  | 95  | 93  |
| HTE/6             | 97.90           | 82  | 96  | 95  |
| HTE/5a            | 96.83           | 82  | 96  | 95  |
| HTE/4b            | 94.90           | 81  | 95  | 94  |
| HTE/3a            | 94.20           | 81  | 95  | 94  |
| TGR-C/19b         | 93.36           | 80  | 94  | 92  |
| TGR-C/19a         | 92.49           | 78  | 91  | 89  |
| TGR-C/18          | 91.84           | 81  | 94  | 93  |
| TGR-C/17a         | 91.18           | 82  | 95  | 94  |
| TGR-C/16b         | 90.49           | 81  | 93  | 92  |
| TGR-C/15          | 89.24           | 83  | 95  | 94  |
| TGR-C/14b<br>trav | 88.49           | 83  | 94  | 93  |
| TGR-C/14b         | 87.96           | 81  | 91  | 90  |
| TGR-C/13d         | 86.91           | 82  | 95  | 94  |
| TGR-C/13b         | 85.86           | 74  | 88  | 85  |
| TGR-C/12          | 84.77           | 72  | 85  | 82  |
| TGR-C/11b         | 84.69           | 81  | 94  | 93  |
| TGR-C/11a         | 84.32           | 72  | 85  | 82  |
| TGR-C/10b         | 84.14           | 72  | 83  | 80  |
| TGR-C/10a         | 83.24           | 74  | 87  | 84  |
| TGR-C/9           | 82.66           | 70  | 83  | 79  |
| TGR-C/8b          | 82.39           | 72  | 86  | 83  |
| TGR-C/8a          | 81.12           | 77  | 91  | 89  |
| TGR-C/7b          | 80.01           | 72  | 86  | 82  |
| TGR-C/6           | 78.97           | 70  | 83  | 79  |
| TGR-C/5           | 78.74           | 72  | 86  | 83  |
| TGR-C/4b          | 78.57           | 78  | 93  | 91  |
| TGR-C/4a          | 77.87           | 70  | 85  | 81  |
| TGR-C/3A          | 77.48           | 76  | 91  | 88  |
| TGR-C/3b          | 76.80           | 70  | 85  | 81  |
| TGR-C/2           | 75.47           | 72  | 87  | 84  |
| TGR-C/1           | 75.13           | 73  | 88  | 85  |
| SHG-D/26b         | 73.05           | 77  | 91  | 89  |
| SHG-D/25          | 72.32           | 78  | 93  | 91  |
| SHG-D/24          | 71.98           | 79  | 94  | 92  |
| SHG-D/23j         | 71.85           | 79  | 93  | 92  |

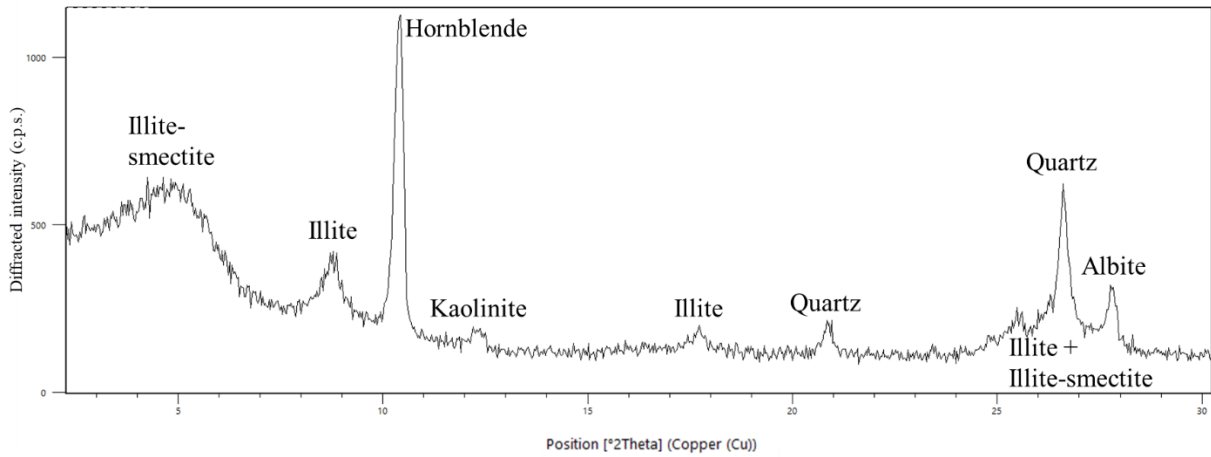
|            |       |    |    |    |
|------------|-------|----|----|----|
| SHG-D/23i  | 71.38 | 77 | 91 | 89 |
| SHG-D/23h  | 70.91 | 79 | 94 | 93 |
| SHG-D/23f  | 69.97 | 79 | 94 | 93 |
| SHG-D/23d  | 69.03 | 73 | 85 | 82 |
| SHG-D/23b  | 68.09 | 75 | 88 | 85 |
| SHG-D/23a  | 67.62 | 78 | 92 | 91 |
| SHG-D/22   | 67.05 | 75 | 89 | 86 |
| SHG-D/21   | 66.70 | 78 | 93 | 92 |
| SHG-D/20a  | 65.83 | 76 | 91 | 89 |
| SHG-D/19   | 65.42 | 76 | 91 | 89 |
| SHG-D/18   | 65.11 | 75 | 89 | 87 |
| SHG-D/17   | 64.93 | 77 | 93 | 91 |
| SHG-D/16b  | 64.30 | 76 | 91 | 89 |
| SHG-D/15   | 63.26 | 76 | 91 | 88 |
| SHG-D/14b  | 62.73 | 75 | 88 | 85 |
| SHG-D/13   | 61.98 | 76 | 89 | 87 |
| SHG-D/12   | 60.80 | 75 | 88 | 86 |
| SHG-D/11b  | 58.45 | 81 | 95 | 93 |
| SHG-D/10   | 57.28 | 80 | 94 | 93 |
| SHG-D/9d   | 57.23 | 78 | 92 | 91 |
| SHG-D/9c   | 56.53 | 79 | 94 | 92 |
| SHG-D/9b   | 55.83 | 75 | 90 | 87 |
| SHG-D/9a   | 55.13 | 72 | 84 | 81 |
| SHG-D/8    | 54.35 | 79 | 95 | 94 |
| SHG-D/7b   | 54.18 | 76 | 91 | 89 |
| SHG-D/6    | 51.43 | 75 | 88 | 85 |
| SHG-D/5    | 50.18 | 78 | 94 | 93 |
| SHG-D/4    | 49.35 | 76 | 93 | 91 |
| SHG-D/3a   | 47.55 | 75 | 91 | 89 |
| SHG-D/2    | 46.68 | 74 | 90 | 88 |
| SHG-D/1    | 45.76 | 73 | 87 | 84 |
| TGR-AB/35  | 40.46 | 73 | 87 | 84 |
| TGR-AB/34b | 39.83 | 76 | 92 | 90 |
| TGR-AB/33b | 38.36 | 76 | 92 | 90 |
| TGR-AB/32l | 37.63 | 76 | 92 | 90 |
| TGR-AB/32j | 35.70 | 75 | 91 | 89 |
| TGR-AB/32i | 34.73 | 76 | 93 | 90 |
| TGR-AB/32h | 33.76 | 75 | 92 | 90 |
| TGR-AB/32f | 31.83 | 75 | 91 | 89 |
| TGR-AB/32d | 29.90 | 72 | 87 | 84 |
| TGR-AB/32a | 27.00 | 75 | 91 | 88 |
| TGR-AB/31  | 25.30 | 74 | 88 | 85 |
| TGR-AB/13  | 8.15  | 76 | 90 | 88 |
| TGR-AB/12  | 7.98  | 80 | 92 | 91 |
| TGR-AB/11a | 6.82  | 72 | 89 | 85 |
| TGR-AB/9   | 3.46  | 77 | 90 | 88 |

42 **Table S4:**  $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$  values of the soil carbonates from the Tsagaan Ovoo Fm., Hsanda  
 43 Gol Fm. and Loh Fm. (Valley of Lakes, Mongolia).

| <b>Sample ID</b> | <b>Position<br/>(m)</b> | <b>BIOZONE</b> | <b><math>\delta^{13}\text{C}_{\text{carb}}</math><br/>(‰, V-PDB)</b> | <b><math>\delta^{18}\text{O}_{\text{carb}}</math><br/>(‰, V-PDB)</b> |
|------------------|-------------------------|----------------|--|--|
| HTE/13a carb     | 108.42                  | biozone D      | -8.1   | -10.2  |
| HTE/12 carb      | 107.65                  | biozone D      | -4.4   | -8.6   |
| HTE/11b carb     | 105.78                  | biozone D      | -5.4   | -8.9   |
| HTE/11a carb     | 104.98                  | biozone D      | -7.3   | -11.0  |
| HTE/9b carb      | 101.38                  | biozone D      | -5.1   | -9.5   |
| HTE/9a carb      | 100.97                  | biozone D      | -6.3   | -11.2  |
| HTE/8 carb       | 100.40                  | biozone D      | -6.1   | -10.6  |
| HTE/7b carb      | 100.00                  | biozone D      | -5.7   | -8.9   |
| HTE/7a carb      | 98.73                   | biozone D      | -6.4   | -11.7  |
| HTE/6 carb       | 97.90                   | biozone C1-D   | -6.3   | -10.3  |
| HTE/5b carb      | 97.50                   | biozone C1-D   | -8.9   | -10.2  |
| TAT/33b          | 96.11                   | biozone C1-D   | -5.3   | -9.6   |
| TAT/33a          | 95.18                   | biozone C1-D   | -4.9   | -9.7   |
| HTE/4b carb      | 94.90                   | biozone C1-D   | -9.0   | -12.9  |
| TAT/32d          | 94.71                   | biozone C1-D   | -4.7   | -8.8   |
| HTE/4a carb      | 94.43                   | biozone C1-D   | -6.3   | -9.6   |
| HTE/3A carb      | 94.20                   | biozone C1-D   | -9.4   | -11.0  |
| TAT/32c          | 94.19                   | biozone C1-D   | -5.1   | -9.6   |
| HTE/3 carb       | 94.00                   | biozone C1-D   | -8.8   | -11.0  |
| TAT/32b          | 93.66                   | biozone C1-D   | -5.4   | -9.5   |
| TGR-C/19b        | 93.36                   | biozone C1-D   | -3.8   | -8.7   |
| TAT/32a          | 93.14                   | biozone C1-D   | -5.1   | -9.0   |
| TAT/31           | 93.07                   | biozone C1-D   | -5.4   | -8.9   |
| TAT/30b          | 92.99                   | biozone C1-D   | -5.6   | -9.4   |
| TGR-C/19a        | 92.49                   | biozone C1-D   | -4.8   | -8.5   |
| TGR-C/18         | 91.84                   | biozone C1     | -4.7   | -7.8   |
| TGR-C/17b        | 91.41                   | biozone C1     | -5.0   | -8.6   |
| TAT/28           | 91.22                   | biozone C1     | -4.9   | -9.0   |
| SHG-D/30         | 91.20                   | biozone C1     | -5.5   | -8.1   |
| TGR-C/17a        | 91.18                   | biozone C1     | -4.5   | -8.3   |
| TAT/27b          | 91.09                   | biozone C1     | -5.4   | -9.5   |
| TGR-C/16c        | 91.06                   | biozone C1     | -4.9   | -8.5   |
| SHG-D/29b        | 91.00                   | biozone C1     | -5.7   | -8.2   |
| SHG-D/29a        | 90.82                   | biozone C1     | -5.4   | -8.8   |
| TAT/27a          | 90.76                   | biozone C1     | -5.2   | -9.3   |
| SHG-D/28a        | 90.18                   | biozone C1     | -5.4   | -8.4   |
| TAT/25           | 90.01                   | biozone C1     | -5.0   | -8.4   |
| SHG-D/26b        | 89.55                   | biozone C1     | -5.6   | -8.8   |
| TGR-C/15         | 89.24                   | biozone C1     | -6.1   | -7.8   |
| SHG-D/26a        | 89.15                   | biozone C1     | -5.5   | -10.3  |
| TAT/23           | 88.81                   | biozone C1     | -5.2   | -9.0   |
| TAT/22d          | 88.64                   | biozone C1     | -5.2   | -9.3   |
| TGR-C/14b        | 88.49                   | biozone C1     | -6.1   | -9.1   |
| TAT/22c          | 87.94                   | biozone C1     | -4.9   | -9.2   |
| TAT/22b          | 87.24                   | biozone C1     | -4.9   | -8.9   |
| TAT/22a          | 86.54                   | biozone C1     | -4.9   | -9.2   |

|           |       |            |      |      |
|-----------|-------|------------|------|------|
| TGR-C/13b | 85.86 | biozone C1 | -5.7 | -9.1 |
| TGR-C/12  | 84.77 | biozone C1 | -5.4 | -7.7 |
| TGR-C/11a | 84.32 | biozone C1 | -6.8 | -9.1 |
| TGR-C/10b | 84.14 | biozone C1 | -5.9 | -9.6 |
| TAT/18a   | 83.87 | biozone C1 | -5.0 | -9.3 |
| TAT/17c   | 83.54 | biozone C  | -4.7 | -8.8 |
| TAT/17b   | 83.24 | biozone C  | -4.8 | -9.0 |
| TGR-C/10a | 83.22 | biozone C  | -5.7 | -7.8 |
| TAT/17a   | 82.94 | biozone C  | -4.8 | -9.2 |
| TGR-C/9   | 82.66 | biozone C  | -5.8 | -8.8 |
| TAT/16b   | 82.64 | biozone C  | -4.8 | -9.7 |
| TGR-C/8b  | 82.39 | biozone C  | -5.6 | -7.6 |
| TAT/16a   | 82.11 | biozone C  | -4.9 | -9.6 |
| TAT/15c   | 81.84 | biozone C  | -4.8 | -9.2 |
| TAT/15b   | 81.26 | biozone C  | -4.2 | -8.6 |
| TGR-C/8a  | 81.12 | biozone C  | -5.8 | -8.3 |
| TAT/15a   | 80.67 | biozone C  | -5.5 | -9.7 |
| TGR-C/7c  | 80.49 | biozone C  | -5.5 | -9.1 |
| TAT/14b   | 80.09 | biozone C  | -4.9 | -9.2 |
| TGR-C/7b  | 80.01 | biozone C  | -5.4 | -9.3 |
| TAT/14a   | 79.59 | biozone C  | -4.9 | -9.0 |
| TGR-C/7a  | 79.52 | biozone C  | -5.9 | -7.6 |
| TAT/12c   | 79.04 | biozone C  | -4.8 | -8.8 |
| TGR-C/6   | 78.97 | biozone C  | -5.9 | -9.2 |
| TGR-C/5   | 78.74 | biozone C  | -5.4 | -9.2 |
| TGR-C/4b  | 78.57 | biozone C  | -5.6 | -8.1 |
| TAT/12b   | 78.47 | biozone C  | -4.8 | -8.6 |
| TAT/12a   | 77.91 | biozone C  | -4.8 | -8.9 |
| TGR-C/4a  | 77.87 | biozone C  | -5.6 | -8.7 |
| TGR-C/3A  | 77.48 | biozone C  | -6.1 | -8.8 |
| TGR-C/3c  | 77.40 | biozone C  | -5.1 | -7.0 |
| TGR-C/3b  | 76.80 | biozone C  | -5.5 | -8.8 |
| TGR-C/3a  | 76.20 | biozone C  | -5.3 | -8.6 |
| TGR-C/2   | 75.47 | biozone C  | -5.9 | -8.6 |
| TGR-C/1   | 75.13 | biozone C  | -5.9 | -9.2 |
| SHG-D/25  | 72.32 | biozone B  | -5.4 | -8.8 |
| SHG-D/24  | 71.98 | biozone B  | -5.2 | -9.3 |
| SHG-D/23j | 71.85 | biozone B  | -5.5 | -8.5 |
| SHG-D/23i | 71.38 | biozone B  | -5.3 | -8.3 |
| SHG-D/23h | 70.91 | biozone B  | -5.4 | -8.5 |
| SHG-D/23g | 70.44 | biozone B  | -5.0 | -8.2 |
| SHG-D/23f | 69.97 | biozone B  | -5.2 | -8.3 |
| SHG-D/23e | 69.50 | biozone B  | -5.3 | -7.9 |
| SHG-D/23d | 69.03 | biozone B  | -5.4 | -8.1 |
| TAT/8c    | 68.99 | biozone B  | -4.7 | -8.7 |
| SHG-D/23c | 68.56 | biozone B  | -4.6 | -7.8 |
| SHG-D/23b | 68.09 | biozone B  | -5.4 | -8.3 |
| TAT/8a    | 68.32 | biozone B  | -4.5 | -8.9 |
| TAT/7b    | 67.99 | biozone B  | -4.7 | -8.8 |
| TAT/7a    | 67.62 | biozone B  | -4.6 | -8.7 |
| SHG-D/23a | 67.61 | biozone B  | -5.0 | -8.9 |
| TAT/6c    | 67.44 | biozone B  | -4.5 | -8.8 |
| TAT/6b    | 67.24 | biozone B  | -4.6 | -8.8 |
| SHG-D/22  | 67.05 | biozone B  | -5.2 | -8.8 |

|            |       |           |      |      |
|------------|-------|-----------|------|------|
| TAT/6a     | 67.04 | biozone B | -4.6 | -8.9 |
| TAT/5      | 66.77 | biozone B | -4.6 | -8.7 |
| SHG-D/21   | 66.70 | biozone B | -5.1 | -9.1 |
| SHG-D/20b  | 66.40 | biozone B | -5.5 | -8.3 |
| TAT/4b     | 66.62 | biozone B | -4.6 | -8.7 |
| TAT/4a     | 66.29 | biozone B | -4.7 | -9.1 |
| TAT/3c     | 66.12 | biozone B | -4.8 | -9.4 |
| SHG-D/20a  | 65.83 | biozone B | -5.8 | -7.9 |
| TAT/3b     | 65.79 | biozone B | -4.5 | -8.3 |
| SHG-D/19   | 65.42 | biozone B | -4.9 | -8.1 |
| SHG-D/18   | 65.11 | biozone B | -5.3 | -8.1 |
| TAT/2      | 65.08 | biozone B | -4.8 | -8.8 |
| TAT/1c     | 65.00 | biozone B | -4.7 | -8.7 |
| SHG-D/17   | 64.93 | biozone B | -5.1 | -9.2 |
| SHG-D/16c  | 64.73 | biozone B | -5.6 | -7.8 |
| TAT/1b     | 64.47 | biozone B | -4.9 | -9.3 |
| SHG-D/16b  | 64.30 | biozone B | -5.6 | -8.3 |
| TAT/1a     | 63.93 | biozone B | -4.8 | -9.1 |
| SHG-D/16a  | 63.86 | biozone B | -5.5 | -7.9 |
| SHG-D/15   | 63.26 | biozone B | -5.1 | -8.6 |
| SHG-D/14b  | 62.73 | biozone B | -5.9 | -8.0 |
| SHG-D/14a  | 62.43 | biozone B | -5.6 | -8.6 |
| SHG-D/13   | 61.98 | biozone B | -5.3 | -7.6 |
| SHG-D/6    | 51.43 | biozone B | -7.3 | -8.5 |
| SHG-D/2    | 46.68 | biozone B | -7.6 | -8.7 |
| TGR-AB/33c | 38.73 | biozone A | -9.2 | -9.1 |
| TGR-AB/33b | 38.36 | biozone A | -8.3 | -8.6 |
| TGR-AB/33a | 38.00 | biozone A | -7.2 | -9.3 |
| TGR-AB/32l | 37.63 | biozone A | -7.5 | -8.4 |
| TGR-AB/32k | 36.66 | biozone A | -7.0 | -8.9 |
| TGR-AB/32j | 35.70 | biozone A | -7.0 | -4.6 |
| TGR-AB/32i | 34.73 | biozone A | -6.8 | -1.5 |
| TGR-AB/32h | 33.76 | biozone A | -6.9 | -7.2 |
| TGR-AB/32g | 32.80 | biozone A | -6.6 | -8.6 |
| TGR-AB/32f | 31.83 | biozone A | -6.8 | -2.6 |
| TGR-AB/32e | 30.86 | biozone A | -6.8 | -0.2 |
| TGR-AB/32d | 29.90 | biozone A | -6.7 | -5.8 |
| TGR-AB/32c | 28.93 | biozone A | -6.4 | -8.4 |
| TGR-AB/32b | 27.96 | biozone A | -7.2 | -6.1 |
| TGR-AB/32a | 27.00 | biozone A | -7.0 | -6.9 |

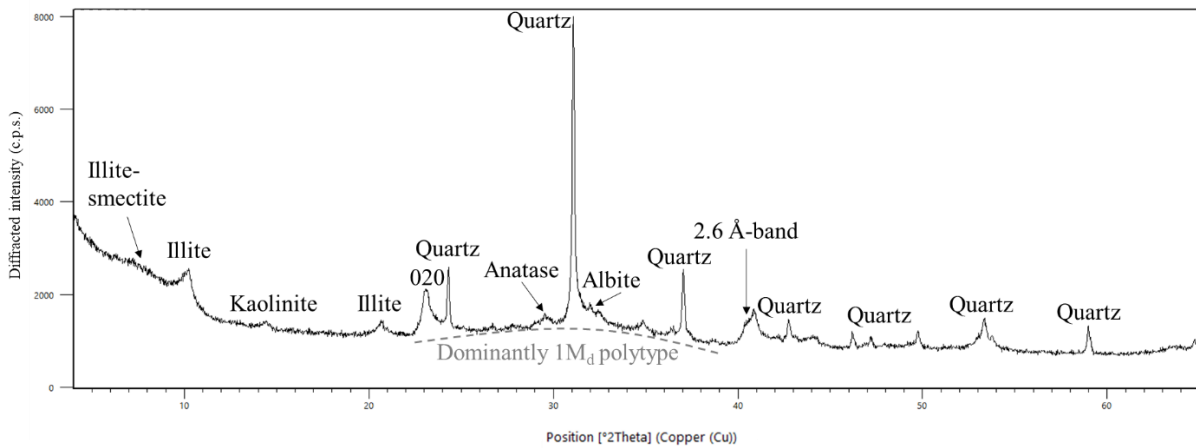


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46 **Figure S1:** XRD pattern (oriented clay film; EG-solvated) of a sample from the TAT section  
 47 (~90.5 m; close to the basalt II group), Hsanda Gol Formation, Valley of Lakes, Mongolia.

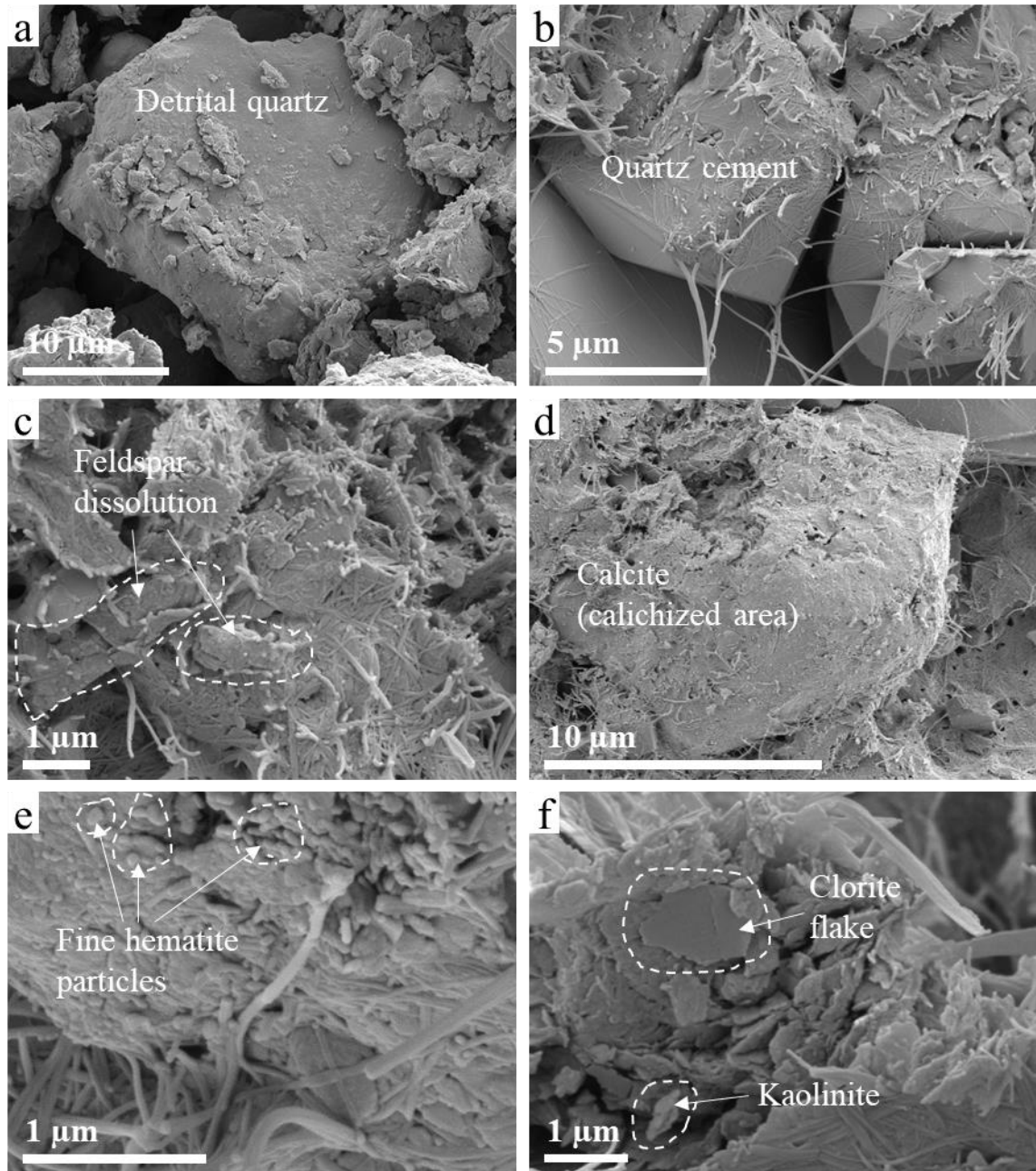
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51 **Figure S2:** XRD pattern (randomly oriented clay preparation) of a sample (carbonate-free; 1-  
 52 2  $\mu\text{m}$  size fraction) from the TGR-C section (~78.0 m), Hsanda Gol Formation, Valley of  
 53 Lakes, Mongolia, demonstrating the dominance of the  $1M_d$  polytype of illite.



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55 **Figure S3:** Secondary electron images of weakly consolidated samples taken from the Hsanda  
 56 Gol Formation, Valley of Lakes, showing (a) (sub)angular to rounded detrital quartz grains, (b)  
 57 diagenetic quartz cement, (c) partially dissolved feldspar grains, (d) calichized areas made of  
 58 calcite spar, (e) fine hematite particles covering detrital components and (f) coarse chlorite  
 59 flakes and tiny rounded kaolinite particles.