**Supplementary Table S4** Chemical composition (wt%) and empirical formulae (apfu) of zircon. For locations of analyses see Figures 2–3. Remark: free space-not analyzed; 0.00- below detection limit of EPMA.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Area | Khan Bogd | | Khalzan Buregte | | Cínovec | | | | | South Bohemian Pluton |
| Rock | granite | | syenite | | biotite granite | | | zinnwaldite granite | | two-mica granite |
| Type | peralkaline rocks | | | | A-type | | | | | S-type |
| Sample | KB4 | KB4 | 6 | 6 | 4962 | 4962 | 4962 | 4971 | 4971 | 2949 |
| **Spot** | **77** | **78** | **34** | **35** | **1** | **2** | **3** | **21** | **22** | **13** |
| WO3 |  |  |  |  |  |  |  | 1.36 | 0.87 | 0.00 |
| P2O5 | 0.18 | 0.20 | 0.28 | 0.28 | 0.86 | 1.04 | 0.76 | 1.58 | 3.02 | 1.09 |
| As2O5 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.02 | 0.02 | 0.12 | 0.30 | 0.00 |
| Nb2O5 | 0.02 | 0.00 | 0.00 | 0.00 |  |  |  | 1.03 | 0.44 | 0.00 |
| SiO2 | 29.19 | 28.81 | 24.08 | 21.64 | 30.36 | 28.43 | 34.82 | 24.19 | 22.26 | 30.74 |
| TiO2 | 0.26 | 0.26 | 0.25 | 0.20 |  |  |  | 0.00 | 0.02 | 0.08 |
| ZrO2 | 58.79 | 57.23 | 49.50 | 45.24 | 58.24 | 57.49 | 37.22 | 33.15 | 39.34 | 63.70 |
| HfO2 | 1.31 | 1.22 | 0.97 | 0.96 | 1.82 | 1.76 | 1.19 | 3.72 | 4.13 | 1.66 |
| ThO2 | 0.31 | 0.34 | 0.02 | 0.00 | 0.14 | 0.18 | 0.12 | 2.84 | 1.53 | 0.05 |
| UO2 | 0.24 | 0.28 | 0.00 | 0.06 | 1.71 | 1.74 | 1.05 | 4.71 | 2.97 | 1.14 |
| Y2O3 | 1.79 | 2.00 | 2.15 | 2.01 | 0.63 | 0.91 | 0.61 | 3.98 | 4.96 | 0.91 |
| La2O3 |  |  |  |  |  |  |  | 0.00 | 0.00 |  |
| Ce2O3 |  |  |  |  |  |  |  | 0.41 | 0.47 |  |
| Pr2O3 |  |  |  |  |  |  |  | 0.00 | 0.06 |  |
| Nd2O3 |  |  |  |  |  |  |  | 0.07 | 0.34 |  |
| Sm2O3 |  |  |  |  |  |  |  | 0.16 | 0.33 |  |
| Gd2O3 | 0.34 | 0.19 | 0.49 | 0.35 |  |  |  | 0.41 | 0.49 |  |
| Dy2O3 | 0.11 | 0.22 | 0.31 | 0.45 |  |  |  | 1.24 | 1.64 | 0.00 |
| Er2O3 | 0.18 | 0.17 | 0.07 | 0.14 |  |  |  | 1.28 | 1.53 | 0.07 |
| Yb2O3 | 0.13 | 0.11 | 0.12 | 0.09 | 0.21 | 0.30 | 0.17 | 2.87 | 3.13 | 0.14 |
| Al2O3 | 0.38 | 0.36 | 0.99 | 0.92 | 0.02 | 0.11 | 7.38 | 0.90 | 0.38 | 0.00 |
| Sc2O3 | 0.00 | 0.02 | 0.04 | 0.02 | 0.30 | 0.33 | 0.19 | 0.27 | 0.42 | 0.26 |
| Bi2O3 |  |  |  |  |  |  |  | 0.12 | 0.03 | 0.02 |
| MnO | 0.16 | 0.18 | 0.10 | 0.08 | 0.06 | 0.15 | 0.07 | 0.02 | 0.07 | 0.04 |
| FeO | 1.03 | 1.20 | 0.41 | 0.38 | 1.27 | 0.72 | 2.37 | 0.16 | 0.45 | 0.30 |
| CaO | 1.33 | 1.39 | 3.67 | 3.28 | 0.24 | 0.52 | 0.47 | 1.10 | 1.45 | 0.23 |
| PbO | 0.08 | 0.12 | 0.02 | 0.01 |  |  |  | 0.02 | 0.05 | 0.06 |
| SO3 | 0.03 | 0.03 | 0.05 | 0.05 |  |  |  | 1.59 | 0.18 |  |
| F | 0.00 | 0.00 | 0.00 | 0.00 |  |  |  | 2.06 | 2.07 | 0.00 |
| **Total** | **95.87** | **94.37** | **83.52** | **76.16** | **95.85** | **93.7** | **86.44** | **89.36** | **92.96** | **100.52** |
| W | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.013 | 0.008 | 0.000 |
| P | 0.005 | 0.006 | 0.009 | 0.010 | 0.024 | 0.029 | 0.021 | 0.051 | 0.096 | 0.029 |
| As | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.006 | 0.000 |
| Nb | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.018 | 0.007 | 0.000 |
| Si | 0.953 | 0.956 | 0.905 | 0.896 | 0.982 | 0.949 | 1.113 | 0.921 | 0.835 | 0.951 |
| Ti | 0.006 | 0.006 | 0.007 | 0.006 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 |
| Zr | 0.936 | 0.926 | 0.907 | 0.913 | 0.919 | 0.936 | 0.580 | 0.615 | 0.719 | 0.961 |
| Hf | 0.012 | 0.012 | 0.010 | 0.011 | 0.017 | 0.017 | 0.011 | 0.040 | 0.044 | 0.015 |
| Th | 0.002 | 0.003 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.025 | 0.013 | 0.000 |
| U | 0.002 | 0.002 | 0.000 | 0.001 | 0.012 | 0.013 | 0.007 | 0.040 | 0.025 | 0.008 |
| Y | 0.031 | 0.035 | 0.043 | 0.044 | 0.011 | 0.016 | 0.010 | 0.081 | 0.099 | 0.015 |
| La | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Ce | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.006 | 0.000 |
| Pr | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| Nd | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.005 | 0.000 |
| Sm | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.004 | 0.000 |
| Gd | 0.004 | 0.002 | 0.006 | 0.005 | 0.000 | 0.000 | 0.000 | 0.005 | 0.006 | 0.000 |
| Dy | 0.001 | 0.002 | 0.004 | 0.006 | 0.000 | 0.000 | 0.000 | 0.015 | 0.020 | 0.000 |
| Er | 0.002 | 0.002 | 0.001 | 0.002 | 0.000 | 0.000 | 0.000 | 0.015 | 0.018 | 0.001 |
| Yb | 0.001 | 0.001 | 0.001 | 0.001 | 0.002 | 0.003 | 0.002 | 0.033 | 0.036 | 0.001 |
| Al | 0.015 | 0.014 | 0.044 | 0.045 | 0.001 | 0.004 | 0.278 | 0.040 | 0.017 | 0.000 |
| Sc | 0.000 | 0.001 | 0.001 | 0.001 | 0.008 | 0.010 | 0.005 | 0.009 | 0.014 | 0.007 |
| Bi | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 |
| Mn | 0.004 | 0.005 | 0.003 | 0.003 | 0.002 | 0.004 | 0.002 | 0.001 | 0.002 | 0.001 |
| Fe | 0.028 | 0.033 | 0.013 | 0.013 | 0.034 | 0.020 | 0.063 | 0.005 | 0.014 | 0.008 |
| Ca | 0.047 | 0.049 | 0.148 | 0.145 | 0.008 | 0.019 | 0.016 | 0.045 | 0.058 | 0.008 |
| Pb | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| S | 0.001 | 0.001 | 0.001 | 0.002 | 0.000 | 0.000 | 0.000 | 0.045 | 0.005 | 0.000 |
| F | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.248 | 0.245 | 0.000 |

Supplementary table 2 cont.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Area | Orlovka | | | Madeira | | | | Europa | | |
| Rock | Bt-granite | | | Ab-granite | | | | Rbk-granite | | |
| Type | A-type granites | | | | | | | peralkaline rocks | | |
| Sample | X-343 | | | PHR-128 | | | | PHR-197 | | |
| **Spot** | **6** | **7** | **8** | **47** | **48** | **49** | **51** | **40** | **41** | **42** |
| WO3 |  |  |  | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| P2O5 | 0.20 | 0.13 | 0.04 | 0.27 | 0.36 | 0.04 | 0.26 | 0.10 | 0.16 | 0.13 |
| As2O5 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Nb2O5 |  |  |  | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SiO2 | 31.71 | 31.61 | 32.03 | 31.65 | 31.51 | 32.06 | 30.44 | 31.66 | 29.11 | 29.64 |
| TiO2 |  |  |  | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.01 |
| ZrO2 | 65.23 | 63.54 | 64.96 | 62.59 | 62.55 | 62.81 | 52.84 | 65.67 | 51.15 | 53.36 |
| HfO2 | 1.24 | 1.52 | 1.93 | 4.86 | 5.26 | 4.48 | 13.99 | 1.18 | 1.29 | 1.45 |
| ThO2 | 0.56 | 0.26 | 0.10 | 0.09 | 0.04 | 0.00 | 0.15 | 0.01 | 0.50 | 0.44 |
| UO2 | 0.39 | 0.52 | 0.38 | 0.00 | 0.02 | 0.03 | 0.00 | 0.06 | 0.73 | 0.66 |
| Y2O3 | 0.41 | 0.41 | 0.12 | 0.15 | 0.28 | 0.00 | 0.26 | 0.55 | 2.14 | 2.40 |
| Dy2O3 |  |  |  | 0.02 | 0.05 | 0.05 | 0.08 | 0.11 | 0.12 | 0.25 |
| Er2O3 |  |  |  | 0.04 | 0.21 | 0.00 | 0.19 | 0.11 | 0.26 | 0.28 |
| Yb2O3 | 0.07 | 0.19 | 0.04 | 0.23 | 0.48 | 0.00 | 0.57 | 0.08 | 0.38 | 0.49 |
| Al2O3 | 0.06 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.86 | 0.89 |
| Sc2O3 | 0.02 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Bi2O3 |  |  |  | 0.01 | 0.00 | 0.04 | 0.01 | 0.00 | 0.14 | 0.15 |
| MnO | 0.06 | 0.05 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.25 | 0.25 |
| FeO | 0.70 | 0.60 | 0.64 | 0.04 | 0.07 | 0.00 | 0.23 | 0.02 | 0.64 | 0.66 |
| CaO | 0.10 | 0.07 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 1.25 | 1.22 |
| PbO |  |  |  | 0.00 | 0.00 | 0.00 | 0.02 | 0.04 | 0.08 | 0.06 |
| SO3 |  |  |  | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.03 |
| F |  |  |  | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| **Total** | **100.73** | **98.91** | **100.23** | **99.98** | **100.84** | **99.53** | **99.06** | **99.61** | **89.1** | **92.36** |
| W | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| P | 0.005 | 0.003 | 0.001 | 0.007 | 0.009 | 0.001 | 0.007 | 0.003 | 0.005 | 0.004 |
| As | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Nb | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Si | 0.977 | 0.990 | 0.990 | 0.989 | 0.981 | 1.001 | 0.999 | 0.982 | 1.008 | 0.995 |
| Ti | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 |
| Zr | 0.980 | 0.970 | 0.979 | 0.953 | 0.950 | 0.957 | 0.846 | 0.994 | 0.864 | 0.874 |
| Hf | 0.011 | 0.014 | 0.017 | 0.043 | 0.047 | 0.040 | 0.131 | 0.010 | 0.013 | 0.014 |
| Th | 0.004 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 | 0.001 | 0.000 | 0.004 | 0.003 |
| U | 0.003 | 0.004 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.006 | 0.005 |
| Y | 0.007 | 0.007 | 0.002 | 0.002 | 0.005 | 0.000 | 0.005 | 0.009 | 0.039 | 0.043 |
| Dy | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.003 |
| Er | 0.000 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.002 | 0.001 | 0.003 | 0.003 |
| Yb | 0.001 | 0.002 | 0.000 | 0.002 | 0.005 | 0.000 | 0.006 | 0.001 | 0.004 | 0.005 |
| Al | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.035 | 0.035 |
| Sc | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Bi | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| Mn | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.007 | 0.007 |
| Fe | 0.018 | 0.016 | 0.016 | 0.001 | 0.002 | 0.000 | 0.006 | 0.001 | 0.019 | 0.019 |
| Ca | 0.003 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.046 | 0.044 |
| Pb | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| S | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| F | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |