Supplementary Material TableSM1

Alkali-F-rich albite zones in evolved NYF pegmatites - the product of melt-melt immiscibility

A. Müller, J. Spratt, R. Thomas, B. J.Williamson, R. Seltmann

Supplementary Material TableSM1. Standards and detection limits (oxides; µgg-1) of electron microprobe analyses.

|  |  |  |
| --- | --- | --- |
| **element** | **standard** | **detection limit of oxide (µgg-1)** |
| Na | Jadeite | 269 |
| K | Potassium Bromide | 240 |
| Ca | Wollastonite | 246 |
| Sc | Scandium Phosphate | 146 |
| V | Vanadite | 196 |
| Cr | Chromium Oxide | 222 |
| Zr | Zircon | 444 |
| La | Lanthanum Glass | 331 |
| Ce | Cerium Glass | 415 |
| Pr | Praesodymium Glass | 680 |
| Nd | Neodymium Glass | 362 |
| Sm | Samarium Glass | 607 |
| Gd | Gadolinium Glass | 741 |
| Dy | Dysprosium Glass | 673 |
| Er | Erbium Glass | 520 |
| Yb | Ytterbium Glass | 536 |
| Si | Fayalite | 133 |
| Al | Corundum | 135 |
| Mg | Forsterite | 114 |
| Y | Yttrium Glass | 282 |
| Ti | Manganese Titanium Oxide | 235 |
| Mn | Manganese Titanium Oxide | 470 |
| Fe | Haematite | 481 |

Supplementary Material TableSM2

Alkali-F-rich albite zones in evolved NYF pegmatites - the product of melt-melt immiscibility

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Supplementary Material TableSM2. List of trace elements for minerals analyzed by LA-ICP-MS including detection limits (LOD), standards and laser parameters.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Mineral | Analyzed isotopes with LOD in parentheses | Standards | | Laser parameters | | |
|  |  | Internal standard | External standards | Spot size | Laser repetition rate | Fluency  (energy density) |
| quartz | 7Li (0.34), 9Be (0.13), 11B (0.35), 23Na (14.24), 27Al (5.56), 31P (1.41), 39K (6.42), 44Ca (36.40), 47Ti (1.54), 55Mn (0.06), 56Fe (0.33), 74Ge (0.10), 85Rb (0.05), 88Sr (0.02) | 29Si using stoichiometric concentration | NIST SRM 610, 612, 614, 616, and 1830, BCS313, BAM Nr. 1 SiO2 glass, Qz-Tu synthetic quartz, | 75 µm | 20 Hz | 6.0-7.0  J · cm-2 |
| fluorite | 23Na (2350), 27Al (1170), 39K(14.3), 44Ca (4150), 55Mn (0.2), 63Cu (1.3), 88Sr (3.1), 89Y (0.01), 90Zr (0.03), 137Ba (0.5), 139La (0.01), 140Ce (0.01), 141Pr (0.01), 143Nd (0.01), 147Sm (0.01), 151Eu (0.01), 157Gd (0.01), 159Tb (0.01), 163Dy (0.01), 165Ho (0.01), 167Er (0.01), 169Tm (0.01), 171Yb (0.01), 175Lu (0.01), 208Pb (0.01), 238U (0.01) | 44Ca using stoichiometric concentration | MAPS4, MAC5, BCS313, NIST SRM 610, 612, 614, and 616 | 75 µm | 20 Hz | 8.0  J · cm-2 |
| topaz, beryl, lepidolite | 7Li (0.4), 9Be (0.3), 11B (0.5), 23Na (6.0), 24Mg (0.8), 27Al (4.0), 31P (5.0), 39K (4.0), 44Ca (12), 45Sc (0.1), 47Ti (1.7), 51V (0.1), 52Cr (0.1), 55Mn (0.1), 56Fe (0.5), 69Ga (0.1), 74Ge (0.2), 85Rb (0.2), 133Cs (0.2) | 29Si using stoichiometric concentration | NIST SRM 610, 612, 614, 616, and 1830, BCS313, BAM Nr. 1 SiO2 glass, Qz-Tu synthetic quartz, | 75 µm | 20 Hz | 6.0-7.0  J · cm-2 |
| columbite- and microlite-group minerals | 24Mg (19.5), 55Mn (0.3), 56Fe (6.1), 89Y (1.1), 118Sn (0.5), 139La (0.01), 140Ce (0.01), 141Pr (0.02), 143Nd (0.02), 147Sm (0.03), 151Eu (0.01), 157Gd (0.03), 159Tb (0.01), 163Dy (0.02), 165Ho (0.01), 167Er (0.02), 169Tm (0.01), 171Yb (0.03), 175Lu (0.01), 209Bi (0.01), 232Th (0.01), 238U (0.01) | 55Mn using Mn values determined by EPMA | BHVO-2G, BCS313, NIST SRM 610, 612, 614, 616, and 1830 | 50 µm | 20 Hz | 4.0-5.0  J · cm-2 |

Supplementary Material TableSM3

Alkali-F-rich albite zones in evolved NYF pegmatites - the product of melt-melt immiscibility

A. Müller, J. Spratt, R. Thomas, B. J.Williamson, R. Seltmann

Supplementary Material TableSM3. Trace element concentrations (µgg-1) in quartz determined with LA-ICP-MS. AZ- albite zone; LOD – Limit of detection.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Li** | **Be** | **B** | **Mn** | **Ge** | **Rb** | **Sr** | **Al** | **P** | **Ti** | **Fe** |
| LOD |  | 0.34 | 0.13 | 0.35 | 0.06 | 0.10 | 0.05 | 0.02 | 5.56 | 1.41 | 1.54 | 0.33 |
| **Topazbrudd** | | | | | | | | | | | | |
| 22091119-A | wall zone | 10.00 | 0.13 | 1.61 | 0.06 | 1.20 | 0.10 | 0.02 | 26.96 | 1.41 | 26.65 | 0.33 |
| 22091119-B | wall zone | 11.56 | 0.13 | 1.22 | 0.06 | 0.99 | 0.05 | 0.02 | 25.74 | 1.41 | 30.10 | 0.33 |
| 22091119-C | wall zone | 9.41 | 0.21 | 1.14 | 0.06 | 1.25 | 0.05 | 0.02 | 33.99 | 1.41 | 29.55 | 0.33 |
| 21061301-A | intermediate zone I | 9.36 | 0.13 | 0.85 | 0.06 | 1.36 | 0.05 | 0.06 | 21.50 | 1.41 | 9.44 | 0.33 |
| 21061301-B | intermediate zone I | 9.60 | 0.13 | 1.26 | 0.18 | 1.65 | 0.05 | 0.05 | 22.01 | 1.41 | 11.80 | 0.33 |
| 21061302-A | intermediate zone II | 8.42 | 0.13 | 1.86 | 0.11 | 4.43 | 0.05 | 0.04 | 30.16 | 1.41 | 5.38 | 0.33 |
| 21061302-B | intermediate zone II | 10.12 | 0.13 | 1.37 | 0.15 | 3.82 | 0.05 | 0.06 | 33.82 | 1.41 | 6.43 | 0.33 |
| 22091118-A | core zone | 5.90 | 0.13 | 1.62 | 0.29 | 7.81 | 0.05 | 0.17 | 35.14 | 1.41 | 6.20 | 0.33 |
| 22091118-B | core zone | 7.42 | 0.26 | 1.50 | 0.06 | 7.51 | 0.05 | 0.05 | 47.49 | 1.41 | 5.31 | 0.33 |
| 22091118-C | core zone | 5.13 | 0.14 | 1.09 | 0.12 | 5.27 | 0.05 | 0.02 | 32.34 | 2.36 | 5.72 | 0.33 |
| 21061303-A | core zone close to AZ | 4.73 | 0.13 | 1.34 | 0.20 | 4.94 | 0.05 | 0.04 | 21.98 | 1.41 | 4.00 | 0.33 |
| 21061303-B | core zone close to AZ | 4.77 | 0.13 | 1.16 | 0.19 | 5.37 | 0.05 | 0.05 | 17.21 | 1.41 | 4.46 | 0.33 |
| **Røykkvartsbrudd** | | | | | | | | | | | | |
| 23091108-A | wall zone | 4.84 | 0.13 | 1.27 | 0.25 | 2.10 | 0.05 | 0.07 | 42.46 | 1.41 | 25.78 | 0.44 |
| 23091108-B | wall zone | 9.52 | 0.13 | 1.11 | 0.06 | 1.75 | 0.05 | 0.12 | 34.18 | 1.41 | 30.44 | 0.33 |
| 23091108-C | wall zone | 7.70 | 0.13 | 1.21 | 0.11 | 1.84 | 0.07 | 0.13 | 39.17 | 4.38 | 27.05 | 0.33 |
| 23091107-A | core zone | 8.08 | 0.40 | 1.89 | 0.24 | 9.18 | 0.11 | 0.18 | 65.74 | 1.41 | 6.25 | 0.58 |
| 23091107-B | core zone | 10.74 | 0.15 | 1.47 | 0.39 | 9.71 | 0.21 | 0.02 | 85.70 | 3.76 | 7.67 | 0.90 |
| 23091107-C | core zone | 13.24 | 0.55 | 2.09 | 1.27 | 7.66 | 0.75 | 0.08 | 90.00 | 1.41 | 7.66 | 1.62 |
| 21061314-A | core zone close to AZ | 10.40 | 0.13 | 3.16 | 0.06 | 7.04 | 0.05 | 0.03 | 21.10 | 1.41 | 1.54 | 0.33 |
| 21061314-B | core zone close to AZ | 8.50 | 0.13 | 2.14 | 0.06 | 7.91 | 0.05 | 0.06 | 22.69 | 1.41 | 1.54 | 0.33 |
| 23091111-A | smoky AZ cavity quartz | 9.28 | 0.13 | 0.94 | 0.06 | 9.93 | 0.05 | 0.24 | 36.43 | 1.41 | 4.13 | 0.40 |
| 23091111-B | smoky AZ cavity quartz | 6.32 | 0.23 | 2.18 | 0.11 | 9.13 | 0.05 | 0.07 | 25.73 | 1.41 | 1.83 | 0.45 |
| 23091111-C | smoky AZ cavity quartz | 7.98 | 0.13 | 1.70 | 0.18 | 9.03 | 0.05 | 0.02 | 30.51 | 1.41 | 1.16 | 0.33 |
| 21091117-A | pink AZ cavity quartz | 7.16 | 0.13 | 1.67 | 0.11 | 6.67 | 0.06 | 0.03 | 11.38 | 2.54 | 1.54 | 0.40 |
| 21091117-B | pink AZ cavity quartz | 3.18 | 0.13 | 1.13 | 0.06 | 6.51 | 0.05 | 0.02 | 5.10 | 1.41 | 1.54 | 0.42 |
| 21091117-C | pink AZ cavity quartz | 2.58 | 0.18 | 0.92 | 0.26 | 6.04 | 0.05 | 0.14 | 9.32 | 2.01 | 1.54 | 0.93 |
| **Solås** | | | | | | | | | | | | |
| 76221-A | wall zone | 12.34 | 0.13 | 0.26 | 0.20 | 1.07 | 0.05 | 0.08 | 41.96 | 1.80 | 27.89 | 0.33 |
| 76221-B | wall zone | 3.85 | 0.21 | 0.80 | 0.23 | 1.37 | 0.05 | 0.07 | 59.79 | 1.41 | 28.93 | 0.33 |
| 76221-C | wall zone | 8.56 | 0.13 | 0.88 | 0.23 | 2.01 | 0.05 | 0.07 | 29.76 | 1.41 | 21.69 | 0.33 |
| 76222-A | intermediate zone I | 9.61 | 0.13 | 0.40 | 0.14 | 1.42 | 0.05 | 0.06 | 26.47 | 1.41 | 14.95 | 0.33 |
| 76222-B | intermediate zone I | 10.07 | 0.13 | 0.58 | 0.23 | 1.29 | 0.05 | 0.10 | 34.94 | 6.77 | 15.07 | 0.33 |
| 76222-C | intermediate zone I | 11.26 | 0.13 | 0.35 | 0.08 | 1.07 | 0.05 | 0.08 | 47.10 | 5.94 | 17.04 | 0.33 |
| 76223-A | intermediate zone II | 11.31 | 0.27 | 0.90 | 0.24 | 2.56 | 0.05 | 0.04 | 27.56 | 3.68 | 19.34 | 0.33 |
| 76223-B | intermediate zone II | 11.31 | 0.13 | 0.65 | 0.08 | 3.48 | 0.05 | 0.03 | 46.63 | 1.41 | 14.53 | 0.35 |
| 76223-C | intermediate zone II | 11.31 | 0.14 | 0.98 | 0.28 | 3.40 | 0.05 | 0.15 | 27.49 | 3.69 | 13.76 | 0.33 |
| 76224-A | core zone | 8.97 | 0.48 | 1.15 | 0.40 | 3.59 | 1.51 | 0.03 | 101.33 | 1.41 | 13.82 | 0.67 |
| 76224-B | core zone | 8.63 | 0.52 | 1.28 | 0.89 | 3.36 | 2.51 | 0.05 | 64.53 | 3.93 | 14.43 | 0.33 |
| 76224-C | core zone | 8.33 | 0.50 | 0.97 | 0.66 | 3.54 | 0.83 | 0.02 | 80.38 | 4.89 | 11.20 | 0.42 |
| 76225-A | core zone close to AZ | 4.21 | 0.13 | 1.26 | 0.19 | 11.37 | 0.05 | 0.07 | 5.56 | 1.41 | 1.54 | 0.33 |
| 76225-B | core zone close to AZ | 7.07 | 0.13 | 1.96 | 0.37 | 11.75 | 0.05 | 0.03 | 23.47 | 3.27 | 1.54 | 0.33 |
| 76225-C | core zone close to AZ | 8.85 | 0.18 | 1.68 | 0.32 | 12.04 | 0.05 | 0.09 | 12.91 | 4.47 | 2.89 | 0.33 |

Supplementary Material TableSM4

Alkali-F-rich albite zones in evolved NYF pegmatites - the product of melt-melt immiscibility

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Supplementary Material TableSM4. Trace element concentrations (µgg-1) of albite-zone-forming topaz determined by LA-ICP-MS. LOD – limit of detection; STDV – standard deviation.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Li | Be | B | Ge | Mg | P | Ti | Mn | Fe | Ga |
| LOD | 0.4 | 0.3 | 0.5 | 0.2 | 0.8 | 5.0 | 1.7 | 0.1 | 0.5 | 0.1 |
| Håvardstad 4b | <0.4 | 4.6 | 1.5 | 402.7 | 3.3 | <5.0 | 5.9 | 0.8 | 12.7 | 6.6 |
|  | <0.4 | <0.3 | 1.2 | 404.9 | 5.7 | 19.8 | 8.1 | 1.5 | 14.4 | 6.8 |
|  | 1.8 | 4.0 | 0.6 | 373.5 | 1.4 | 20.8 | 6.3 | 0.9 | 7.9 | 5.4 |
|  | <0.4 | 0.9 | 0.7 | 372.9 | 5.3 | 13.3 | 5.6 | 1.4 | 9.7 | 5.2 |
|  | <0.4 | 2.5 | 1.4 | 396.1 | 5.6 | 24.3 | 9.5 | 3.1 | 10.5 | 5.6 |
|  | <0.4 | <0.3 | 0.6 | 399.6 | 4.3 | 26.7 | 7.8 | 0.9 | 9.1 | 5.3 |
| **average** | **≤0.6** | **≤2.1** | **1.0** | **391.6** | **4.3** | **≤18.3** | **7.2** | **1.4** | **10.7** | **5.8** |
| STDV |  |  | **0.4** | **14.6** | **1.7** |  | **1.5** | **0.9** | **2.4** | **0.7** |
| Ivar Gruve | 1.3 | 8.9 | <0.5 | 199.8 | 6.6 | 34.6 | 10.0 | 0.7 | 55.5 | 5.1 |
|  | 0.8 | 1.0 | 1.6 | 199.3 | 5.6 | 36.9 | 18.2 | 0.2 | 52.2 | 5.2 |
|  | 3.8 | 1.6 | 0.7 | 195.5 | 7.7 | 28.5 | 16.7 | 0.7 | 53.6 | 4.7 |
|  | 0.9 | <0.3 | 0.6 | 185.3 | 5.1 | 14.5 | 19.0 | 0.2 | 51.7 | 5.3 |
|  | 1.4 | 1.0 | <0.5 | 194.4 | 8.3 | 31.1 | 20.3 | 0.4 | 52.8 | 6.0 |
|  | 1.0 | 1.8 | 0.9 | 197.6 | 4.0 | 14.2 | 22.7 | 0.6 | 58.6 | 5.8 |
| **average** | **1.5** | **≤2.4** | **≤0.8** | **195.3** | **6.2** | **26.6** | **17.8** | **0.5** | **54.1** | **5.4** |
| STDV | **1.1** |  |  | **5.3** | **1.6** | **10.0** | **4.3** | **0.2** | **2.6** | **0.5** |
| Birkeland 4 | 0.9 | 11.3 | <0.5 | 302.5 | 4.3 | 26.0 | 23.5 | 0.1 | 56.8 | 8.7 |
|  | 4.1 | 6.1 | 0.9 | 306.0 | 5.9 | 21.6 | 14.1 | 0.3 | 54.9 | 8.9 |
|  | 0.6 | <0.3 | <0.5 | 298.3 | 1.5 | 39.0 | 14.4 | 0.2 | 57.1 | 8.3 |
|  | <0.4 | <0.3 | <0.5 | 294.0 | 4.4 | 25.9 | 8.8 | 0.1 | 59.5 | 8.3 |
|  | 26.8 | 3.9 | 2.6 | 317.1 | 2.3 | 34.0 | 11.1 | 0.2 | 55.2 | 8.7 |
|  | 1.0 | <0.3 | <0.5 | 296.2 | 4.2 | 6.0 | 16.5 | 0.1 | 56.2 | 7.2 |
| **average** | **≤5.6** | **≤4.3** | **≤0.8** | **302.4** | **3.8** | **25.4** | **14.7** | **0.2** | **56.6** | **8.3** |
| STDV |  |  |  | **8.4** | **1.6** | **11.4** | **5.1** | **0.1** | **1.7** | **0.6** |
| Topazbrudd | 0.7 | 3.6 | <0.5 | 301.1 | 2.4 | 5.6 | 7.6 | 0.3 | 37.7 | 5.5 |
|  | 1.6 | 7.7 | 1.2 | 296.9 | 3.5 | 9.7 | 22.9 | 0.3 | 43.4 | 5.7 |
|  | 0.7 | 2.2 | <0.5 | 302.2 | 4.3 | 8.6 | 15.2 | 0.1 | 38.9 | 3.5 |
|  | 1.2 | 2.1 | 0.9 | 297.9 | 2.8 | 13.4 | 11.4 | 0.2 | 42.4 | 5.0 |
|  | 1.3 | <0.3 | <0.5 | 303.9 | 5.2 | 23.1 | 12.1 | 0.2 | 39.8 | 5.4 |
|  | 1.0 | 1.0 | <0.5 | 286.2 | 5.3 | 12.8 | 10.7 | 0.3 | 44.3 | 5.8 |
| **average** | **1.1** | **≤2.8** | **≤0.7** | **298.0** | **3.9** | **12.2** | **13.3** | **0.2** | **41.1** | **5.1** |
| STDV | **0.4** |  |  | **6.4** | **1.2** | **6.1** | **5.3** | **0.1** | **2.6** | **0.9** |
| Solås | 1.6 | 4.2 | <0.5 | 483.1 | 6.4 | 36.2 | 18.4 | 0.2 | 46.4 | 7.8 |
|  | <0.4 | <0.3 | <0.5 | 478.5 | 3.7 | 22.3 | 8.8 | 0.1 | 50.4 | 8.4 |
|  | <0.4 | <0.3 | 0.6 | 311.9 | 6.5 | 30.3 | 7.5 | 0.2 | 45.7 | 6.4 |
|  | <0.4 | 4.3 | <0.5 | 311.6 | 4.5 | 21.7 | 12.8 | 0.1 | 50.9 | 6.0 |
|  | <0.4 | 9.9 | <0.5 | 346.9 | 2.1 | 44.1 | 17.7 | 0.1 | 55.2 | 8.0 |
|  | <0.4 | <0.3 | 0.6 | 283.4 | 4.4 | 41.7 | 12.5 | 0.1 | 47.4 | 4.8 |
| **average** | **≤0.6** | **≤3.2** | **≤0.5** | **369.2** | **4.6** | **32.7** | **13.0** | **0.1** | **49.4** | **6.9** |
| STDV |  |  |  | **88.7** | **1.7** | **9.6** | **4.5** | **0.1** | **3.6** | **1.4** |