Highly retentive core domains in K-feldspar and their implications for ⁴⁰Ar/³⁹Ar thermochronology illustrated by determining the cooling curve for the Capoas Granite, Palawan, The Philippines

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SUPPLEMENTARY PAPERS

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SUPPLEMENTARY PAPERS

Appendix 1 ⁴⁰Ar/³⁹Ar Geochronology analytical procedures (Capoas Granite). Appendix 2 ⁴⁰Ar/³⁹Ar geochronology data: Sample 11, PAL33a, K-Feldspar. Appendix 3 Scanning Electron Microprobe data: on the Hitachi 4300 FESEM.

APPENDIX 1 ⁴⁰Ar/³⁹Ar geochronology analytical procedures (Capoas Granite)

Sample PAL33

Two K-feldspar samples from sample PAL33 (PAL33a with 107.8 mg and PAL33b with 71.9 mg) have been analysed using the furnace step-heating diffusional experiments technique at the ANU RSES Argon Laboratory (argon.anu.edu.au).

Large feldspar phenocrysts were cut out of PAL33 and processed separately from the feldspars in the groundmass. Mineral separates were done at RSES, preparing samples PAL33a and PAL33b. Both samples were then crushed, sieved to a specific size split (150–350 μ m) and separated using heavy liquid to purify the grains and then hand-picked to ~99.9% purity.

Irradiation of samples for ⁴⁰Ar/³⁹Ar analysis was undertaken at the McMaster Nuclear Reactor, Ontario, Canada. Irradiation was for 3 hours and 12 minutes in position 5C at 2.5 MW; A Cadmium liner was used to minimize interference from thermal neutrons. K-feldspar (Sanidine 92-176) was used as the Flux Monitor (Spell & McDougall 2003). Samples and flux monitors were wrapped in aluminium for irradiation. Aluminium foil was removed from samples and they were rewrapped in tin for analysis in the mass spectrometer, so as to be able to melt the tin wrap and pump away the contaminated gases prior to the analysis of a sample. The ⁴⁰Ar/³⁹Ar analysis procedures are as described by McDougall & Brown (2006). Grains were analysed using the step-heating method using the furnace technique with temperature control monitored via a thermocouple at the base of a tantalum crucible within a double-vacuum resistance furnace. Analysis was done with liquid nitrogen Cold Trap to reduce contamination into the line and mass spectrometer.

The K-feldspars were analysed on a VG1200 gas source mass spectrometer with a Multiplier. Machine discrimination was determined and used in the data reduction process. Line blanks were measured at different temperatures prior to analysis and backgrounds measured for every step; these were subtracted from final analysis.

Samples were heated prior to analysis with heating up to ~400°C then reduced to 380°C overnight. This is done to outgas contaminants at lower temperatures to minimize mixing contaminants with radiogenic argon released from low retentivity sites into the initial analytical steps. This contaminated gas was pumped away prior to analysis.

K-feldspars were then analysed as diffusion experiments with 35–36 steps, with two or more isothermal steps throughout most of the schedule, and with temperatures of the overall schedule rising from 450°C to 1450°C (Lovera *et al.* 1989). The furnace was decontaminated prior to each sample at 1450°C for 15 minutes three times. The gases from the cleaning process were pumped away and not exposed to the extraction line.

Flux monitors were analysed using a continuous wave laser and the VG1200 Mass Spectrometer, with backgrounds subtracted. Gas released from each step is exposed to Zr–Al getters to remove active gases for 10 minutes, the purified gas then being isotopically analysed in the mass spectrometer.

⁴⁰K abundances and decay constants are taken from standard values recommended by the IUGS subcommission on Geochronology (Steiger & Jaeger 1977). Stated precisions for ⁴⁰Ar/³⁹Ar ages include all uncertainties in the measurement of isotope ratios and are quoted at the 1-sigma level. The method of asymptotes and limits was used in analysis of the data from this study (Forster & Lister 2004) due to the complex character of the apparent age spectra and the inadequacies of traditional plateau methods when mixing ages are present. The method of asymptotes and limits has been automated using a MacOS *eArgon* (written by G. Lister @ RSES).

Irradiation times, flux monitor, correction factors:

The samples were irradiated at the McMaster Nuclear Reactor, Ontario, Canada, as CAN ANU #7. Irradiated position 5C for 8.0 MWh with cadmium shielding.

⁴⁰K abundances and decay constants are taken from Steiger & Jaeger (1977).

Flux monitor: Sanidine 92-176 @ 28.10 Ma ± 0.04 Ma (Spell & McDougall 2003).

Discrimination Factor: (1 amu) 1.01890 \pm 0.41% (calculated using a linear equation).

Corrections factors were calculated by interaction of neutrons with K and Ca:

 (Ar^{36}/Ar^{37}) Ca correction factor 4.39^{E-04} (Ca F₂)

 (Ar^{39}/Ar^{37}) Ca correction factor 7.17^{E-04} (Ca F₂)

 (Ar^{40}/Ar^{39}) K correction factor 5.94^{E-02} (K₂ SO₄)

 (Ar^{38}/Ar^{39}) K correction factor 1.20^{E-02} (K₂ SO₄)

Average J = 9.8872^{E-4} (J/MWh) = 1.2359^{E-4}

Ca/K conversion factor 1.90

Lambda K⁴⁰ 5.5430^{E-10}

Analysis of samples was done using a liquid nitrogen trap. Canister irradiated in position 5C at McMaster Reactor, Canada. Irradiation time was 8 MWh on 12 August 2011. Canister had cadmium shielding.

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| Temp | Ar36 | err | Ar37 | err | Ar38 | err | Ar39 | err | Ar40 | err | % | Ar40*/ | Cumulative | Calculated Age | | | | |
|-------|----------|------|----------|-------|----------|------|----------|------|----------|------|-------|---------|------------|----------------|---|------|----------|----------|
| (C) | (mol) | (%) | (mol) | (%) | (mol) | (%) | (mol) | (%) | (mol) | (%) | Ar40* | Ar39(K) | Ar39(%) | Ma ± 1 s.d. | | Ca/K | CI/K | |
| 450 | 1.17E-15 | 1.29 | 2.29E-16 | 3.35 | 2.44E-16 | 0.74 | 1.05E-15 | 0.21 | 3.76E-13 | 0.48 | 8.30 | 29.83 | 0.02 | 52.58 | ± | 7.98 | 4.16E-01 | 4.28E-01 |
| 450 | 2.57E-16 | 1.52 | 3.04E-16 | 3.21 | 6.51E-17 | 1.57 | 3.15E-16 | 0.73 | 7.49E-14 | 0.84 | -1.50 | 0.00 | 0.03 | 0.00 | ± | 7.48 | 1.85E+00 | 1.53E+00 |
| 500 | 1.09E-15 | 1.26 | 7.17E-17 | 18.07 | 2.84E-16 | 1.20 | 4.48E-15 | 0.16 | 4.59E-13 | 0.46 | 29.80 | 30.50 | 0.13 | 53.75 | ± | 1.77 | 3.04E-02 | 2.10E-01 |
| 500 | 1.78E-16 | 1.61 | 3.26E-16 | 6.12 | 5.89E-17 | 1.51 | 1.09E-15 | 0.12 | 5.60E-14 | 0.54 | 6.20 | 3.19 | 0.16 | 5.69 | ± | 1.46 | 5.69E-01 | 4.22E-01 |
| 550 | 1.08E-15 | 1.26 | 2.19E-17 | 14.74 | 3.72E-16 | 0.66 | 1.12E-14 | 0.07 | 5.25E-13 | 0.44 | 39.00 | 18.24 | 0.41 | 32.33 | ± | 0.73 | 3.70E-03 | 1.11E-01 |
| 550 | 4.23E-16 | 1.53 | 2.94E-16 | 4.71 | 2.07E-16 | 0.79 | 9.44E-15 | 0.15 | 1.86E-13 | 0.45 | 32.60 | 6.42 | 0.63 | 11.45 | ± | 0.39 | 5.91E-02 | 5.39E-02 |
| 600 | 7.02E-16 | 1.25 | 1.45E-16 | 5.06 | 3.86E-16 | 0.50 | 1.91E-14 | 0.13 | 4.06E-13 | 0.44 | 48.90 | 10.41 | 1.07 | 18.53 | ± | 0.29 | 1.44E-02 | 4.81E-02 |
| 600 | 2.62E-16 | 1.50 | 2.65E-16 | 9.13 | 3.40E-16 | 0.80 | 2.20E-14 | 0.13 | 2.29E-13 | 0.44 | 66.10 | 6.88 | 1.57 | 12.26 | ± | 0.12 | 2.29E-02 | 4.41E-02 |
| 650 | 5.05E-16 | 1.25 | 1.23E-16 | 2.40 | 5.72E-16 | 0.43 | 3.78E-14 | 0.12 | 4.63E-13 | 0.45 | 67.60 | 8.27 | 2.43 | 14.74 | ± | 0.13 | 6.16E-03 | 2.23E-02 |
| 650 | 1.43E-16 | 1.32 | 1.80E-16 | 3.52 | 6.00E-16 | 0.51 | 4.59E-14 | 0.06 | 3.71E-13 | 0.44 | 88.40 | 7.14 | 3.48 | 12.73 | ± | 0.07 | 7.43E-03 | 1.80E-02 |
| 700 | 2.93E-16 | 1.24 | 1.48E-15 | 1.52 | 8.34E-16 | 0.70 | 6.23E-14 | 0.17 | 5.62E-13 | 0.46 | 84.40 | 7.62 | 4.91 | 13.58 | ± | 0.08 | 4.50E-02 | 1.91E-02 |
| 700 | 5.45E-16 | 1.26 | 8.05E-15 | 0.93 | 2.62E-15 | 0.49 | 2.00E-13 | 0.11 | 1.63E-12 | 0.43 | 90.00 | 7.35 | 9.47 | 13.09 | ± | 0.07 | 7.66E-02 | 2.28E-02 |
| 750 | 3.56E-17 | 1.43 | 3.88E-16 | 0.97 | 3.74E-16 | 0.43 | 2.96E-14 | 0.13 | 2.26E-13 | 0.45 | 95.20 | 7.26 | 10.15 | 12.94 | ± | 0.06 | 2.49E-02 | 1.53E-02 |
| 750 | 8.45E-17 | 1.85 | 1.92E-15 | 1.22 | 6.45E-16 | 0.52 | 4.88E-14 | 0.21 | 3.71E-13 | 0.46 | 93.10 | 7.09 | 11.26 | 12.64 | ± | 0.06 | 7.48E-02 | 3.32E-02 |
| 800 | 8.98E-17 | 1.50 | 2.07E-15 | 1.82 | 6.56E-16 | 0.97 | 4.95E-14 | 0.09 | 3.80E-13 | 0.43 | 92.90 | 7.13 | 12.39 | 12.71 | ± | 0.06 | 7.92E-02 | 3.33E-02 |
| 800 | 1.01E-16 | 1.82 | 7.93E-17 | 26.89 | 7.35E-16 | 0.44 | 5.73E-14 | 0.12 | 4.41E-13 | 0.43 | 93.00 | 7.16 | 13.70 | 12.77 | ± | 0.06 | 2.63E-03 | 1.84E-02 |
| 850 | 7.85E-17 | 1.38 | 1.46E-15 | 1.47 | 6.19E-16 | 0.53 | 4.88E-14 | 0.06 | 3.80E-13 | 0.42 | 93.70 | 7.31 | 14.82 | 13.03 | ± | 0.06 | 5.68E-02 | 1.42E-02 |
| 850 | 8.94E-17 | 1.27 | 5.34E-16 | 1.95 | 6.98E-16 | 0.43 | 5.61E-14 | 0.13 | 4.38E-13 | 0.45 | 93.80 | 7.32 | 16.10 | 13.04 | ± | 0.06 | 1.81E-02 | 5.63E-03 |
| 900 | 1.20E-16 | 1.65 | 3.52E-16 | 2.47 | 6.30E-16 | 0.51 | 4.91E-14 | 0.13 | 3.93E-13 | 0.45 | 90.80 | 7.26 | 17.22 | 12.93 | ± | 0.07 | 1.36E-02 | 1.37E-02 |
| 900 | 1.72E-16 | 1.30 | 1.26E-15 | 0.87 | 8.74E-16 | 0.56 | 6.66E-14 | 0.05 | 5.33E-13 | 0.42 | 90.30 | 7.23 | 18.74 | 12.89 | ± | 0.06 | 3.59E-02 | 2.38E-02 |
| 950 | 2.99E-16 | 1.39 | 2.79E-16 | 1.57 | 8.68E-16 | 0.43 | 6.51E-14 | 0.02 | 5.71E-13 | 0.41 | 84.30 | 7.39 | 20.23 | 13.18 | ± | 0.07 | 8.14E-03 | 1.74E-02 |
| 950 | 3.68E-16 | 1.26 | 4.35E-16 | 1.33 | 1.24E-15 | 0.45 | 9.34E-14 | 0.18 | 7.96E-13 | 0.47 | 86.20 | 7.35 | 22.36 | 13.10 | ± | 0.08 | 8.85E-03 | 1.88E-02 |
| 1000 | 6.64E-16 | 1.24 | 7.43E-16 | 1.22 | 1.62E-15 | 0.42 | 1.21E-13 | 0.10 | 1.11E-12 | 0.44 | 82.10 | 7.55 | 25.12 | 13.45 | ± | 0.08 | 1.17E-02 | 1.47E-02 |
| 1000 | 6.52E-16 | 1.43 | 2.46E-15 | 1.06 | 2.12E-15 | 0.55 | 1.62E-13 | 0.16 | 1.40E-12 | 0.46 | 86.10 | 7.46 | 28.81 | 13.29 | ± | 0.08 | 2.90E-02 | 1.42E-02 |
| 1100 | 2.80E-15 | 1.26 | 5.38E-15 | 1.88 | 1.10E-14 | 0.44 | 8.46E-13 | 0.15 | 7.34E-12 | 0.45 | 88.50 | 7.68 | 48.15 | 13.68 | ± | 0.07 | 1.21E-02 | 1.23E-02 |
| 1100 | 1.47E-15 | 1.28 | 2.08E-18 | 5.95 | 9.34E-15 | 0.81 | 7.46E-13 | 0.26 | 6.08E-12 | 0.51 | 92.70 | 7.55 | 65.20 | 13.45 | ± | 0.08 | 5.29E-03 | 5.47E-03 |
| 1100 | 1.02E-15 | 1.66 | 4.96E-15 | 1.41 | 7.55E-15 | 0.62 | 5.94E-13 | 0.26 | 4.80E-12 | 0.50 | 93.50 | 7.57 | 78.77 | 13.49 | ± | 0.07 | 1.59E-02 | 1.45E-02 |
| 1150 | 1.00E-15 | 1.37 | 4.22E-15 | 2.10 | 7.39E-15 | 0.46 | 5.83E-13 | 0.06 | 4.79E-12 | 0.48 | 93.60 | 7.69 | 92.10 | 13.70 | ± | 0.07 | 1.37E-02 | 1.29E-02 |
| 1150 | 6.25E-16 | 1.27 | 1.37E-18 | 1.94 | 3.72E-15 | 0.43 | 2.86E-13 | 0.11 | 2.38E-12 | 0.49 | 92.00 | 7.64 | 98.64 | 13.62 | ± | 0.07 | 9.12E-03 | 2.22E-02 |
| 1150 | 1.73E-16 | 1.69 | 7.85E-17 | 1.59 | 5.07E-16 | 1.99 | 3.83E-14 | 0.38 | 3.38E-13 | 0.61 | 84.70 | 7.47 | 99.52 | 13.31 | ± | 0.10 | 3.89E-03 | 1.41E-02 |
| 1150 | 1.26E-16 | 1.35 | 8.84E-17 | 5.46 | 1.80E-16 | 0.54 | 1.27E-14 | 0.06 | 1.33E-13 | 0.44 | 71.80 | 7.53 | 99.81 | 13.41 | ± | 0.11 | 1.33E-02 | 1.14E-02 |
| 1200 | 2.92E-17 | 1.83 | 1.87E-19 | 1.81 | 3.80E-17 | 5.09 | 1.06E-15 | 0.52 | 1.29E-14 | 1.38 | 33.10 | 4.02 | 99.83 | 7.17 | ± | 0.40 | 3.34E-02 | 6.87E-01 |
| 1250 | 2.99E-17 | 5.61 | 1.87E-19 | 5.66 | 2.68E-17 | 9.25 | 8.27E-16 | 5.33 | 1.22E-14 | 6.03 | 27.70 | 4.10 | 99.85 | 7.32 | ± | 1.92 | 4.30E-02 | 5.04E-01 |
| 1300 | 2.90E-17 | 2.63 | 2.51E-16 | 4.69 | 2.93E-17 | 5.74 | 5.76E-16 | 0.62 | 9.41E-15 | 1.40 | 9.20 | 1.52 | 99.86 | 2.71 | ± | 0.81 | 8.31E-01 | 1.09E+00 |
| 1350 | 3.16E-17 | 3.05 | 1.87E-19 | 2.24 | 2.98E-17 | 6.01 | 5.53E-16 | 1.13 | 9.92E-15 | 1.34 | 5.90 | 1.05 | 99.88 | 1.89 | ± | 1.01 | 6.43E-04 | 1.15E+00 |
| 1450 | 1.19E-16 | 1.26 | 1.87E-19 | 4.59 | 9.69E-17 | 1.82 | 5.42E-15 | 0.26 | 7.42E-14 | 0.50 | 52.60 | 7.19 | 100.00 | 12.82 | ± | 0.19 | 6.56E-05 | 6.50E-02 |
| Total | 1.69E-14 | | 3.84E-14 | | 5.75E-14 | | 4.38E-12 | | 3.84E-11 | | | 7.61 | | 13.56 | ± | 0.08 | | |

Appendix 2 ⁴⁰Ar/³⁹Ar geochronology data: Sample 11, PAL33a, K-Feldspar

Lambda K40=5.5430E-10 J=9.9147E-4; %error J=0.794

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Appendix 2 - ⁴⁰Ar/³9Ar geochronology data: Sample 12, PAL33b, K-Feldspar

| Temp | Ar36 | err | Ar37 | err | Ar38 | err | Ar39 | err | Ar40 | err | % | Ar40*/ | Cumulative | Calculated Age | | Ca/K | CI/K | |
|------|----------|------|----------|--------|----------|-------|----------|------|----------|------|-------|---------|------------|----------------|---|--------|----------|-----------|
| (C) | (mol) | (%) | (mol) | (%) | (mol) | (%) | (mol) | (%) | (mol) | (%) | Ar40* | Ar39(K) | Ar39(%) | Ma | ± | 1 s.d. | | |
| 450 | 9.76E-17 | 1.84 | 1.36E-16 | 16.08 | 2.27E-17 | 2.65 | 3.33E-16 | 1.26 | 3.39E-14 | 1.39 | 15.00 | 15.31 | 0.02 | 27.12 | ± | 3.75 | 7.78E-01 | 3.58E-02 |
| 450 | 3.37E-17 | 1.86 | 9.54E-17 | 16.57 | 5.03E-18 | 17.18 | 8.02E-17 | 1.36 | 9.66E-15 | 1.42 | -3.10 | 0.00 | 0.03 | 0.00 | ± | 5.14 | 2.28E+00 | -1.05E+00 |
| 500 | 2.04E-16 | 2.04 | 1.11E-19 | 135.12 | 6.53E-17 | 1.61 | 1.88E-15 | 0.41 | 1.03E-13 | 1.25 | 41.60 | 22.77 | 0.11 | 40.18 | ± | 1.65 | 1.12E-02 | 8.72E-02 |
| 500 | 5.04E-17 | 1.90 | 1.08E-16 | 1.80 | 1.44E-17 | 86.92 | 3.83E-16 | 0.56 | 1.73E-14 | 0.73 | 14.00 | 6.33 | 0.12 | 11.26 | ± | 1.43 | 5.36E-01 | 3.55E-02 |
| 550 | 3.86E-16 | 1.41 | 1.24E-16 | 4.78 | 1.85E-16 | 0.83 | 8.42E-15 | 0.26 | 2.23E-13 | 0.54 | 48.90 | 12.95 | 0.52 | 22.97 | ± | 0.42 | 2.81E-02 | 5.16E-02 |
| 600 | 2.55E-16 | 1.35 | 2.21E-16 | 2.86 | 1.80E-16 | 2.02 | 1.01E-14 | 0.27 | 1.89E-13 | 0.51 | 60.20 | 11.32 | 0.98 | 20.09 | ± | 0.25 | 4.17E-02 | 4.33E-02 |
| 600 | 1.14E-16 | 2.03 | 6.96E-17 | 214.69 | 1.40E-16 | 1.61 | 9.29E-15 | 1.27 | 9.23E-14 | 1.98 | 63.40 | 6.30 | 1.41 | 11.21 | ± | 0.37 | 1.42E-02 | 2.75E-02 |
| 650 | 1.78E-16 | 1.36 | 7.78E-17 | 11.46 | 2.30E-16 | 0.54 | 1.56E-14 | 0.13 | 1.85E-13 | 0.46 | 71.40 | 8.50 | 2.12 | 15.10 | ± | 0.13 | 9.49E-03 | 2.28E-02 |
| 650 | 8.62E-17 | 1.34 | 1.53E-16 | 9.51 | 2.56E-16 | 0.57 | 1.90E-14 | 0.22 | 1.52E-13 | 0.48 | 83.10 | 6.67 | 2.99 | 11.86 | ± | 0.08 | 1.53E-02 | 2.32E-02 |
| 700 | 1.41E-16 | 1.62 | 1.18E-16 | 5.69 | 3.57E-16 | 1.45 | 2.58E-14 | 0.08 | 2.45E-13 | 0.46 | 82.90 | 7.87 | 4.18 | 13.99 | ± | 0.09 | 8.70E-03 | 2.93E-02 |
| 700 | 5.65E-17 | 1.50 | 1.38E-16 | 7.23 | 3.69E-16 | 0.73 | 2.92E-14 | 0.12 | 2.21E-13 | 0.44 | 92.20 | 6.97 | 5.51 | 12.40 | ± | 0.06 | 8.99E-03 | 1.06E-02 |
| 750 | 1.05E-16 | 1.35 | 1.51E-16 | 6.38 | 4.85E-16 | 0.48 | 3.74E-14 | 0.14 | 3.09E-13 | 0.44 | 89.80 | 7.41 | 7.23 | 13.18 | ± | 0.07 | 7.65E-03 | 1.67E-02 |
| 750 | 4.52E-17 | 2.30 | 1.13E-16 | 8.14 | 5.46E-16 | 0.46 | 4.34E-14 | 0.15 | 3.24E-13 | 0.45 | 95.70 | 7.13 | 9.22 | 12.68 | ± | 0.06 | 4.95E-03 | 1.41E-02 |
| 800 | 7.18E-17 | 1.29 | 1.65E-16 | 2.96 | 5.63E-16 | 0.47 | 4.36E-14 | 0.09 | 3.37E-13 | 0.42 | 93.50 | 7.21 | 11.22 | 12.83 | ± | 0.06 | 7.18E-03 | 2.18E-02 |
| 800 | 4.02E-17 | 1.33 | 1.90E-16 | 1.22 | 5.53E-16 | 0.59 | 4.45E-14 | 0.39 | 3.30E-13 | 0.56 | 96.20 | 7.14 | 13.26 | 12.70 | ± | 0.07 | 8.10E-03 | 1.01E-02 |
| 850 | 5.22E-17 | 1.41 | 1.48E-16 | 2.90 | 4.36E-16 | 0.45 | 3.45E-14 | 0.12 | 2.66E-13 | 0.43 | 94.00 | 7.24 | 14.84 | 12.87 | ± | 0.06 | 8.16E-03 | 1.31E-02 |
| 850 | 4.22E-17 | 1.44 | 2.60E-16 | 1.48 | 4.20E-16 | 0.46 | 3.36E-14 | 0.04 | 2.55E-13 | 0.42 | 94.90 | 7.21 | 16.38 | 12.82 | ± | 0.06 | 1.47E-02 | 9.71E-03 |
| 900 | 4.66E-17 | 1.37 | 2.56E-16 | 2.76 | 3.36E-16 | 0.68 | 2.58E-14 | 0.17 | 2.00E-13 | 0.46 | 92.90 | 7.19 | 17.57 | 12.78 | ± | 0.06 | 1.88E-02 | 2.55E-02 |
| 900 | 4.86E-17 | 1.77 | 1.77E-16 | 7.13 | 3.62E-16 | 0.60 | 2.86E-14 | 0.08 | 2.18E-13 | 0.42 | 93.20 | 7.11 | 18.88 | 12.65 | ± | 0.06 | 1.17E-02 | 1.30E-02 |
| 950 | 6.81E-17 | 1.53 | 2.39E-16 | 5.83 | 3.32E-16 | 0.84 | 2.54E-14 | 0.04 | 2.01E-13 | 0.41 | 89.80 | 7.10 | 20.04 | 12.62 | ± | 0.06 | 1.79E-02 | 2.16E-02 |
| 950 | 8.26E-17 | 2.01 | 2.29E-16 | 1.37 | 4.36E-16 | 0.82 | 3.33E-14 | 0.07 | 2.62E-13 | 0.42 | 90.50 | 7.12 | 21.57 | 12.65 | ± | 0.06 | 1.30E-02 | 2.27E-02 |
| 1000 | 1.35E-16 | 1.37 | 2.06E-16 | 5.91 | 4.47E-16 | 0.49 | 3.37E-14 | 0.10 | 2.84E-13 | 0.43 | 85.80 | 7.22 | 23.11 | 12.84 | ± | 0.07 | 1.16E-02 | 1.89E-02 |
| 1000 | 1.77E-16 | 1.60 | 1.70E-16 | 3.74 | 6.20E-16 | 0.63 | 4.80E-14 | 0.06 | 4.03E-13 | 0.43 | 86.80 | 7.30 | 25.31 | 12.98 | ± | 0.07 | 6.72E-03 | 9.04E-03 |
| 1100 | 9.10E-16 | 1.24 | 1.16E-19 | 1.99 | 2.20E-15 | 0.44 | 1.63E-13 | 0.13 | 1.51E-12 | 0.44 | 82.00 | 7.60 | 32.78 | 13.51 | ± | 0.08 | 1.35E-03 | 1.80E-02 |
| 1100 | 6.50E-16 | 1.41 | 3.43E-16 | 4.65 | 2.03E-15 | 0.70 | 1.56E-13 | 0.11 | 1.36E-12 | 0.43 | 85.70 | 7.52 | 39.91 | 13.37 | ± | 0.07 | 4.19E-03 | 9.72E-03 |
| 1100 | 5.05E-16 | 1.27 | 5.08E-16 | 4.01 | 1.86E-15 | 0.54 | 1.43E-13 | 0.19 | 1.22E-12 | 0.45 | 87.60 | 7.53 | 46.44 | 13.39 | ± | 0.07 | 6.78E-03 | 1.34E-02 |
| 1150 | 5.24E-16 | 1.33 | 1.16E-19 | 1.86 | 2.25E-15 | 0.51 | 1.63E-13 | 0.11 | 1.42E-12 | 0.44 | 88.90 | 7.73 | 53.93 | 13.75 | ± | 0.07 | 1.35E-03 | 2.37E-02 |
| 1150 | 6.38E-16 | 1.41 | 3.22E-17 | 14.40 | 3.48E-15 | 0.74 | 2.74E-13 | 0.23 | 2.33E-12 | 0.52 | 91.70 | 7.81 | 66.50 | 13.88 | ± | 0.08 | 2.23E-03 | 9.04E-03 |
| 1150 | 5.14E-16 | 1.58 | 3.22E-19 | 22.00 | 3.58E-15 | 0.55 | 2.83E-13 | 0.23 | 2.33E-12 | 0.67 | 93.30 | 7.71 | 79.46 | 13.70 | ± | 0.10 | 2.17E-03 | 1.18E-02 |
| 1150 | 3.44E-16 | 1.82 | 5.20E-17 | 35.59 | 2.64E-15 | 0.61 | 2.08E-13 | 0.13 | 1.68E-12 | 0.53 | 93.80 | 7.57 | 89.01 | 13.46 | ± | 0.08 | 4.75E-03 | 1.34E-02 |
| 1200 | 1.97E-16 | 1.37 | 2.19E-16 | 7.91 | 1.55E-15 | 0.53 | 1.21E-13 | 0.07 | 9.92E-13 | 0.43 | 93.90 | 7.68 | 94.57 | 13.65 | ± | 0.06 | 3.42E-03 | 1.71E-02 |
| 1250 | 1.23E-16 | 1.49 | 1.18E-17 | 17.47 | 1.26E-15 | 0.51 | 1.00E-13 | 0.18 | 8.15E-13 | 0.68 | 95.40 | 7.76 | 99.17 | 13.79 | ± | 0.10 | 2.24E-04 | 1.16E-02 |
| 1300 | 2.43E-17 | 3.48 | 2.09E-16 | 4.98 | 9.82E-17 | 2.08 | 7.61E-15 | 0.23 | 6.34E-14 | 0.51 | 88.50 | 7.37 | 99.51 | 13.11 | ± | 0.10 | 5.21E-02 | 1.14E-02 |
| 1350 | 3.51E-17 | 3.10 | 1.44E-16 | 8.36 | 1.05E-16 | 1.00 | 8.10E-15 | 0.25 | 6.89E-14 | 0.50 | 84.80 | 7.21 | 99.89 | 12.81 | ± | 0.10 | 3.38E-02 | 5.98E-03 |
| 1450 | 2.73E-17 | 6.78 | 6.36E-16 | 6.74 | 3.63E-17 | 9.28 | 2.49E-15 | 0.67 | 2.62E-14 | 0.89 | 69.40 | 7.31 | 100.00 | 13.00 | ± | 0.42 | 4.85E-01 | 1.89E-02 |
| Tota | 7.04E-15 | | 5.74E-15 | | 2.85E-14 | | 2.18E-12 | | 1.87E-11 | | | 7.61 | | 13.52 | ± | 0.08 | | |

Lambda K40=5.5430E-10 J=9.8928E-4; %error J=0.796

Appendix 3 Scanning Electron Microprobe data: on the Hitachi 4300 FESEM.

| Spectrum | Weight % | Weight % | Weight % | Weight % | Weight % | Weight % | Weight % | Weight % | Weight% | Weight% | Number |
|--------------------------------|----------------|----------------|----------------|----------------|---------------|----------|----------|----------------|---------|----------|--------------|
| | Na K SERIES | Mg K SERIES | AI K SERIES | SI K SERIES | K K SERIES | K SERIES | K SERIES | Fe K SERIES | 0 | Iotai | of lons O |
| Figure 3a | | | | | | | | | | | |
| Spot 1 | 6.1146 | 0.0000 | 9.9318 | 31.4323 | 2.0110 | 0.0695 | 0.0000 | 0.0000 | 47.2108 | 96.7700 | 8 |
| Spot 2 | 2.7542 | 0.0000 | 9.6480 | 30.0049 | 8.3607 | 0.1136 | 0.0000 | 0.0000 | 45.4795 | 96.3608 | 8 |
| Spot 1 repeat | 6.0668 | 0.0000 | 10.1088 | 31.6861 | 1.9217 | 0.0000 | 0.0000 | 0.0000 | 47.5946 | 97.3779 | 8 |
| Spot 2 repeat | 1.5673 | 0.0000 | 9.5959 | 29.9824 | 11.1416 | 0.1374 | 0.0000 | 0.0000 | 45.5730 | 97.9977 | 8 |
| Figure 3b | | | | | | | | | | | |
| Spot 7 | 7.5787 | 0.0000 | 10.8239 | 31.0721 | 1.4417 | 0.3098 | 0.0000 | 0.0000 | 48.0828 | 99.3090 | 8 |
| Spot 8 (quartz) | 0.0000 | 0.0000 | 1.2640 | 44.2783 | 1.7291 | 0.0000 | 0.0000 | 0.0000 | 51.9237 | 99.1951 | 8 |
| Spot 7 repeat | 7.3118 | 0.0000 | 12.0529 | 30.7321 | 0.0000 | 2.2536 | 0.0000 | 0.0000 | 49.1766 | 101.5270 | 8 |
| High Na area | 4.8828 | 0.0000 | 10.1469 | 31.5279 | 6.6335 | 0.0000 | 0.0000 | 0.0000 | 48.0004 | 101.1916 | 8 |
| High K av. | 1.8090 | 0.0000 | 10.0165 | 31.0767 | 11.0173 | 0.0000 | 0.0000 | 0.0000 | 47.1976 | 101.1170 | 8 |
| large area | | | | | | | | | | | |
| High K av. | 2.0456 | 0.0000 | 10.2587 | 31.3582 | 10.5062 | 0.0000 | 0.0000 | 0.0000 | 47.7114 | 101.8800 | 8 |
| small area | | | | | | | | | | | |
| Figure 3c | | | | | | | | | | | |
| Spot 17 | 7.2716 | 0.0000 | 11.3691 | 30.5828 | 0.3605 | 2.0423 | 0.0000 | 0.0000 | 48.3737 | 100.0000 | 8 |
| Spot 18 | 1.9242 | 0.0000 | 9.9225 | 30.8134 | 10.5759 | 0.0000 | 0.0000 | 0.0000 | 46.7639 | 100.0000 | 8 |
| Spot 18 repeat | 1.8245 | 0.0000 | 9.9031 | 30.4776 | 11.3144 | 0.0000 | 0.0000 | 0.0000 | 46.4804 | 100.0000 | 8 |
| Spot 18 repeat | 0.0000 | 0.0000 | 8.2658 | 33.6199 | 10.3438 | 0.0000 | 0.0000 | 0.0000 | 47.7706 | 100.0000 | 8 |
| Spot 18 repeat | 0.0000 | 0.0000 | 9.4583 | 30.5442 | 13.9355 | 0.0000 | 0.0000 | 0.0000 | 46.0620 | 100.0000 | 8 |
| Spot 18 repeat | 0.0000 | 0.0000 | 10.4501 | 31.7988 | 10.1517 | 0.0000 | 0.0000 | 0.0000 | 47.5994 | 100.0000 | 8 |
| Spot 18 repeat | 1.1646 | 0.0000 | 9.7414 | 30.6388 | 12.0203 | 0.0000 | 0.0000 | 0.0000 | 46.4349 | 100.0000 | 8 |
| STANDARDS | | | | | | | | | | | |
| Albite | 8.5658 | 0.0000 | 10.3036 | 32.1476 | 0.1767 | 0.0000 | 0.0000 | 0.0000 | 48.8063 | 100.0000 | 8 |
| Albite | 8.6436 | 0.0000 | 10.2385 | 32.0358 | 0.1577 | 0.0000 | 0.0000 | 0.1961 | 48.7284 | 100.0000 | 8 |
| Sanidine | 2.2433 | 0.0000 | 10.0735 | 30.4024 | 10.0579 | 0.0000 | 0.2073 | 0.3094 | 46.7063 | 100.0000 | 8 |
| Garnet | 0.0000 | 5.8176 | 11.3883 | 17.7870 | 0.0000 | 2.8193 | 0.0000 | 18.7733 | 43.4146 | 100.0000 | 8 |
| Fe ₂ O ₃ | 0.0000 | 0.0000 | 0.1253 | 0.0634 | 0.0000 | 0.0000 | 0.0000 | 69.6834 | 30.1279 | 100.0000 | 8 |
| TiO ₂ | 0.0000 | 0.0000 | 0.0636 | 0.0493 | 0.0000 | 0.0000 | 59.8162 | 0.0000 | 40.0709 | 100.0000 | 8 |
| Diopside | 0.0000 | 11.2057 | 0.0000 | 26.0322 | 0.0000 | 18.3892 | 0.0000 | 0.0000 | 44.3729 | 100.0000 | 8 |
| MgO | 0.0000 | 60.1632 | 0.0539 | 0.0671 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 39.7159 | 100.0000 | 8 |

Samples used for scanning electron microscopy and elemental analysis were prepared by mounting them in 25.4 mm resin discs followed by polishing to <0.5 µm finish, they were then coated with ~20 nm of carbon. Compositional analysis was performed using a Hitachi 4300 FESEM equipped with an Oxford Instruments XMax, 80 mm² Silicon Drift Detector (SDD) and Oxford INCA software. All analyses were carried out at 15 kV and 0.6 nA of probe current using well characterised minerals as reference standards (Astimex). Atomic number, absorption, and fluorescence corrections were applied throughout.