

Supplementary Information for paper “Large-scale liquid immiscibility in the Siberian flood basalts recorded in native iron” by Kamenetsky et al.

Method: The composition of immiscible phases were analysed using a Cameca SX100 electron microprobe at the University of Tasmania. The instrument is equipped with a tungsten filament source and 5 wavelength dispersive spectrometers. The data were obtained using the “Probe for EPMA” software. Analytical conditions of the analyses were 15kV acceleration voltage, a beam current of 20nA and a static beam with a diameter of 10-50µm (depending of the size of the phase), to account for the heterogeneities in the liquids caused by the formation of small quench crystals during cooling and to reduce element migration. Elements were acquired using K α lines and analysing crystals LLIF for Fe, Mn, Ti, Cr, Ni, LPET for P, K, Ca, and TAP for Al, Si, Na, Mg. The standards were Bustamite for Mn, Hematite for Fe, Rutile for Ti, Nickel Silicide for Ni (all Astimex Scientific Ltd), Clinopyroxene for Si and Ca (Delegate, Australia), Olivine (San Carlos) for Mg, Plagioclase (Labradorite) for Al, Chromite (Tiebaghi) for Cr, (K-)Anorthoclase (Kakanui) for Na, Microcline for K, and Apatite (Durango) for P (all Smithsonian standards). Counting times were 20 seconds on peak and background for Na, Fe, Mn, Ti, K, Ca, P, Al and Si, and 30 seconds on peak and background for Mg, Cr and Ni. The background correction method was slope (high) for Mn and P, and linear for all other elements. Oxygen was calculated by cation stoichiometry and included in the matrix correction^{1,2}. The mass absorption coefficients dataset was LINEMU³ <10 keV and CITZMU⁴ >10 keV.

Table S1: The compositions (in wt%) of immiscible conjugate liquids represented by matrix (M) and globular (G) finely crystalline phases.

| Sample | M/G | Type | SiO ₂ | TiO ₂ | Al ₂ O ₃ | FeO | MnO | MgO | CaO | Na ₂ O | K ₂ O | P ₂ O ₅ | total |
|----------|-----|------|------------------|------------------|--------------------------------|-------|------|------|-------|-------------------|------------------|-------------------------------|--------|
| Sl1_MP7 | G | Lsi | 59.25 | 1.19 | 15.75 | 7.77 | 0.13 | 2.34 | 7.05 | 4.15 | 0.67 | 1.48 | 99.78 |
| | M | Lfe | 45.77 | 2.68 | 12.17 | 14.85 | 0.27 | 5.53 | 10.88 | 2.75 | 0.33 | 4.85 | 100.07 |
| Sl1_MP11 | M | Lsi | 64.99 | 1.37 | 15.14 | 4.84 | 0.07 | 0.97 | 2.74 | 4.15 | 3.34 | 0.82 | 98.43 |
| | G | Lfe | 38.93 | 6.15 | 10.11 | 19.31 | 0.31 | 4.87 | 12.48 | 0.72 | 0.19 | 6.00 | 99.06 |
| Sl1_MP1 | M | Lsi | 66.41 | 1.08 | 15.57 | 4.16 | 0.06 | 0.72 | 2.37 | 4.26 | 3.72 | 0.78 | 99.12 |
| | G | Lfe | 36.74 | 6.10 | 9.34 | 21.76 | 0.31 | 4.84 | 11.72 | 0.94 | 0.35 | 7.48 | 99.57 |
| Sl1_MP10 | M | Lsi | 65.83 | 0.62 | 15.09 | 4.30 | 0.12 | 1.16 | 3.44 | 4.75 | 2.68 | 0.70 | 98.69 |
| | G | Lfe | 37.89 | 2.48 | 7.86 | 20.50 | 0.59 | 6.73 | 13.24 | 1.51 | 0.36 | 8.95 | 100.09 |
| Sl1_MP4 | G | Lsi | 62.17 | 0.69 | 15.95 | 5.73 | 0.11 | 2.19 | 6.21 | 4.31 | 0.86 | 1.65 | 99.87 |
| | M | Lfe | 42.95 | 1.65 | 11.29 | 15.27 | 0.33 | 5.99 | 12.18 | 1.54 | 1.03 | 7.81 | 100.05 |
| Sl1_MP3 | G | Lsi | 62.57 | 0.67 | 16.08 | 6.24 | 0.09 | 1.70 | 5.64 | 4.25 | 0.78 | 1.30 | 99.33 |
| | M | Lfe | 33.73 | 2.07 | 8.81 | 21.17 | 0.31 | 6.76 | 14.41 | 1.12 | 0.43 | 12.17 | 100.98 |
| Sl1_MP9 | M | Lsi | 65.92 | 0.72 | 14.37 | 4.13 | 0.20 | 1.39 | 3.33 | 3.67 | 3.20 | 0.67 | 97.61 |
| | G | Lfe | 31.57 | 2.91 | 6.85 | 21.95 | 0.58 | 7.00 | 14.16 | 0.94 | 0.16 | 12.21 | 98.33 |
| Sl1_MP12 | M | Lsi | 66.60 | 0.72 | 15.89 | 3.80 | 0.13 | 1.22 | 4.12 | 4.42 | 1.51 | 1.02 | 99.45 |
| | G | Lfe | 27.57 | 2.66 | 6.38 | 20.43 | 0.53 | 7.88 | 17.05 | 0.82 | 0.65 | 16.88 | 100.84 |
| Sl1_MP16 | G | Lsi | 68.50 | 0.62 | 16.77 | 2.73 | 0.10 | 0.67 | 2.76 | 4.77 | 1.27 | 1.41 | 99.61 |
| | M | Lfe | 26.61 | 2.12 | 6.74 | 18.64 | 0.37 | 5.97 | 19.37 | 1.23 | 0.03 | 19.19 | 100.26 |
| VSh_MP12 | M | Lsi | 76.46 | 0.52 | 12.49 | 0.76 | 0.17 | 0.35 | 0.38 | 3.58 | 4.72 | 0.55 | 99.96 |
| | G | Lfe | 15.14 | 2.66 | 2.64 | 15.00 | 0.86 | 5.51 | 26.69 | 1.46 | 0.00 | 30.23 | 100.17 |
| Mt_MP15 | G | Lsi | 70.58 | 0.69 | 12.94 | 2.43 | 0.11 | 0.54 | 1.96 | 3.55 | 3.59 | 0.55 | 96.96 |
| | M | Lfe | 22.11 | 3.55 | 4.53 | 18.23 | 0.75 | 6.77 | 21.54 | 0.54 | 0.02 | 20.78 | 98.83 |
| Mt_MP16 | G | Lsi | 69.25 | 0.53 | 14.40 | 3.49 | 0.12 | 0.93 | 3.33 | 4.50 | 1.35 | 0.68 | 98.58 |
| | M | Lfe | 28.15 | 2.23 | 5.82 | 18.34 | 0.62 | 8.10 | 17.50 | 1.06 | 0.13 | 16.59 | 98.54 |
| Mt_MP18 | G | Lsi | 67.00 | 1.06 | 16.93 | 1.87 | 0.05 | 0.54 | 6.14 | 2.60 | 0.86 | 1.37 | 98.44 |
| | M | Lfe | 17.84 | 3.46 | 4.42 | 18.53 | 0.48 | 9.66 | 19.65 | 0.72 | 0.02 | 23.88 | 98.67 |
| Mt_MP26 | M | Lsi | 66.01 | 0.79 | 14.74 | 4.06 | 0.15 | 1.43 | 3.25 | 4.21 | 1.69 | 0.95 | 97.27 |
| | G | Lfe | 24.53 | 3.23 | 6.01 | 20.45 | 0.59 | 8.53 | 17.15 | 0.88 | 0.04 | 17.57 | 98.98 |
| Mt_MP10 | G | Lsi | 67.74 | 0.82 | 13.72 | 4.42 | 0.10 | 1.20 | 0.49 | 4.20 | 3.57 | 0.64 | 96.90 |
| | M | Lfe | 17.24 | 3.43 | 3.78 | 18.75 | 0.62 | 8.44 | 21.02 | 0.87 | 0.02 | 24.26 | 98.43 |
| Mt_MP24 | G | Lsi | 67.87 | 1.25 | 15.77 | 9.14 | 0.09 | 1.55 | 0.64 | 1.18 | 0.04 | 1.01 | 98.54 |
| | M | Lfe | 22.28 | 6.45 | 6.21 | 19.38 | 0.35 | 4.89 | 19.35 | 1.09 | 0.01 | 18.84 | 98.84 |
| Sl2_MP18 | M | Lsi | 68.08 | 0.65 | 15.43 | 2.63 | 0.09 | 0.69 | 2.94 | 5.36 | 1.24 | 0.98 | 98.08 |
| | G | Lfe | 21.69 | 2.93 | 4.72 | 19.04 | 0.66 | 7.88 | 21.21 | 0.69 | 0.09 | 20.86 | 99.77 |
| Sl2_MP20 | M | Lsi | 71.54 | 0.52 | 15.35 | 0.79 | 0.03 | 0.02 | 1.01 | 4.09 | 3.93 | 0.68 | 97.95 |
| | G | Lfe | 14.46 | 1.41 | 2.60 | 15.95 | 0.52 | 4.05 | 30.39 | 1.06 | 0.08 | 27.74 | 98.25 |

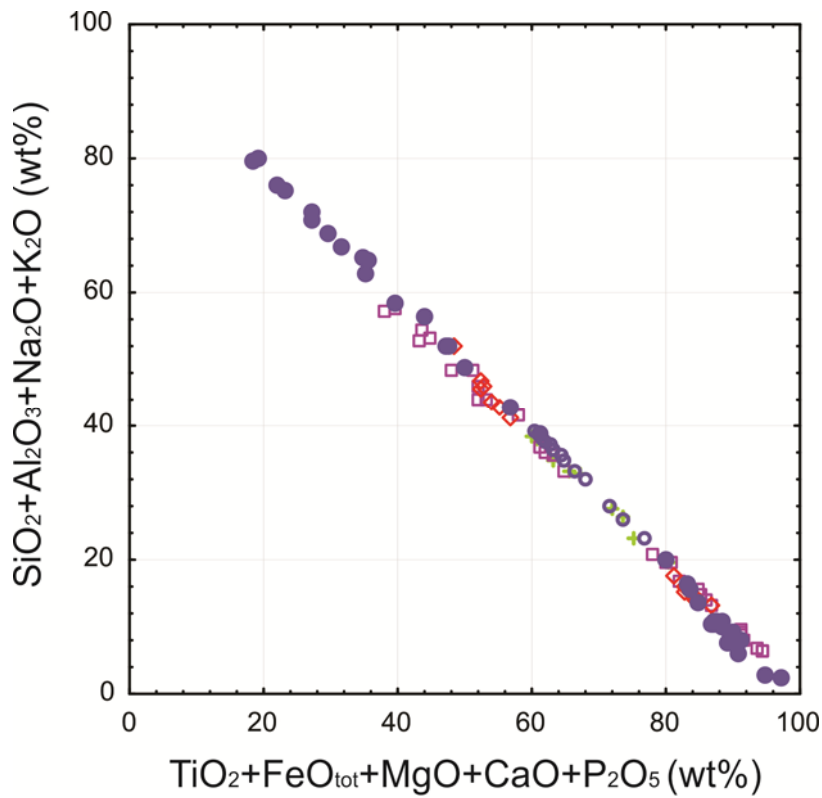
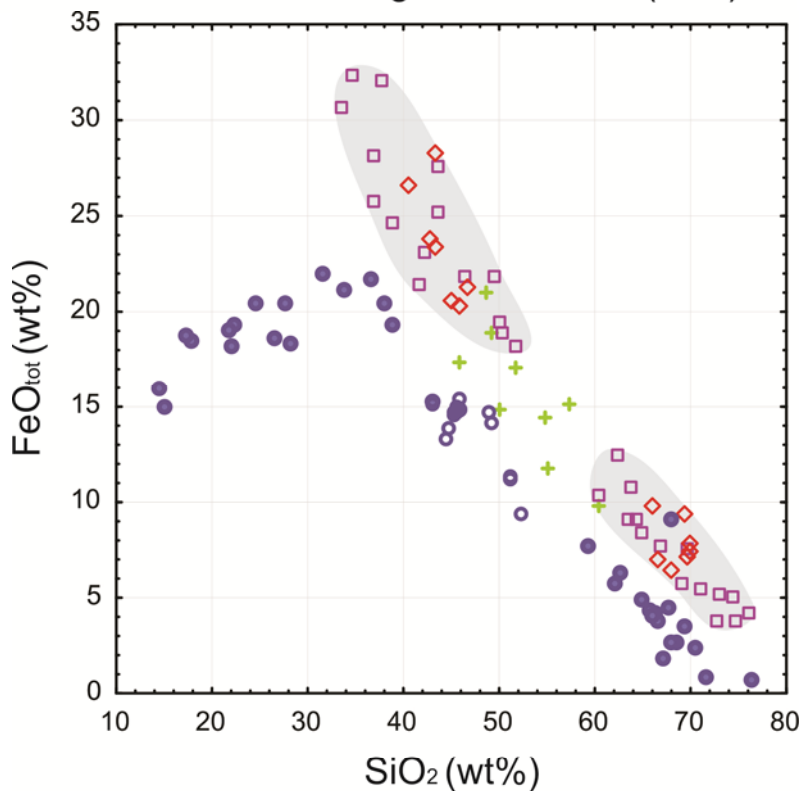


Figure S1. The compositions of the conjugate liquids in the melt pools from the Khungtukun native iron are compared with the Siberian flood basalts from the Maimecha-Kotui magmatic province and experimental data on liquid immiscibility in tholeiitic systems.

The SiO_2 vs FeO diagram shows that the bulk composition of individual melt pools in native iron cannot be the same, as the trend is inflected at ~ 35 wt% SiO_2 . It is assumed that the bulk compositions evolved along a common trend for tholeiitic basalts (i.e. Si-enrichment, Fe-depletion trend). This is supported by pronounced Fe depletion of the L_{Fe} phase in highly contrasted melt pairs that equilibrated at the lowest temperature (Fig. S2).

Note that the two-liquid stability fields in the Siberian basalts and experimental tholeiitic systems occur at lower and higher FeO, respectively, for a given SiO_2 , thus reflecting differences in FeO content of the “starting” melts.



Immiscible melts

◇ Dixon & Rutherford, 1979

□ Charlier & Grove, 2012

● this study

*Homogeneous melts
before immiscibility*

+ Charlier & Grove, 2012

○ Siberian basalts

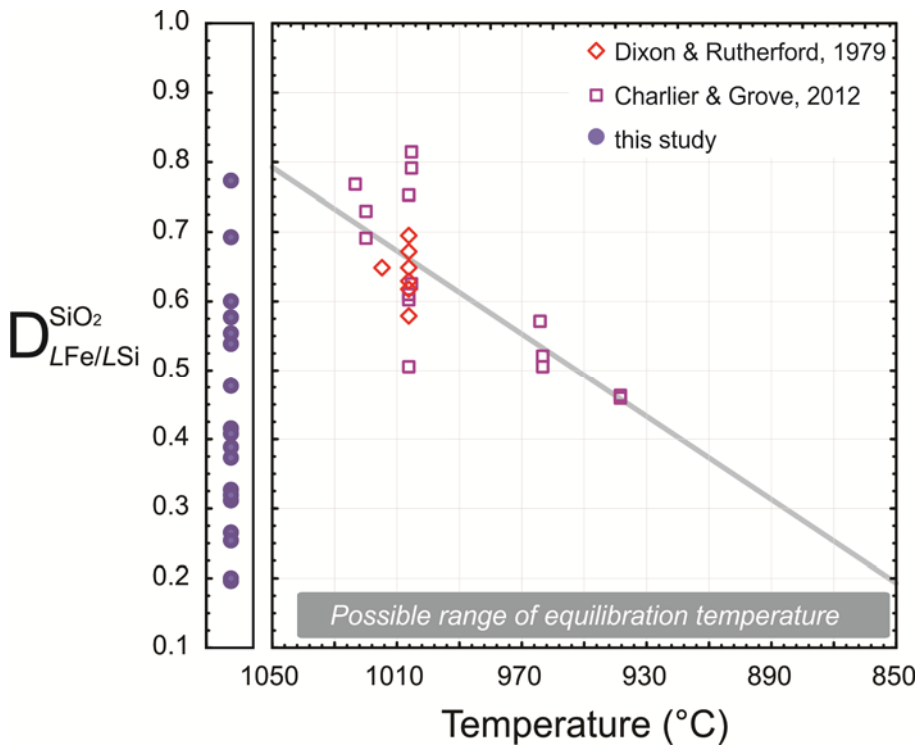


Fig. S2.

Figure S2. Partitioning of SiO_2 between experimental iron-rich and the silica-rich melts as a function of equilibration temperature ($^{\circ}\text{C}$). The possible range of equilibration temperature for immiscible melts in Siberian basalts is calculated using the linear regression based on experimental data^{5,6}.

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