

First trace elemental composition of silicic fluid films around mineral inclusions in gem-quality diamonds

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Diamonds crystallize from fluids or melts circulating in the Earth's mantle. Analysis of these fluids is possible if they remain entrapped in diamonds during growth, but this is rarely observed in gem-quality stones. We investigated thin silicic fluid films ($\leq 5 \mu\text{m}$) surrounding mineral inclusions in gem-quality diamonds from the Siberian Craton, as previously reported by Nimis et al. (2016).

Raman spectroscopy identified one omphacite, eight olivine, and four Mg-chromite inclusions. Confocal micro-Raman mapping reveals a variable 3D distribution of the fluid, containing $\text{Si}_2\text{O}(\text{OH})_6$ and $\text{Si}(\text{OH})_4$ around the inclusions. The coexistence of peridotitic and eclogitic inclusions from different cratonic regions highlights a strong connection between this fluid and gem-quality lithospheric diamond formation. The silicic nature of the fluid surrounding silicate and non-silicate inclusions, particularly Mg-chromite, excludes post-entrapment reactions or decompression-driven exsolution. This confirms that the silicic fluid is a residue of metasomatic diamond-forming reactions.

Using a diamond from the Siberian Craton, we conducted slow LA-ICPMS depth profiling ($\sim 70 \mu\text{m}$) to analyse the fluid film at the diamond-inclusion interface. Detectable elements include Ba, Sr, Ce, Nb, La, Nd, and Th, providing the first direct evidence of the fluid's elemental composition. Contributions from the underlying olivine inclusion were monitored via Mg and Fe. The fluids trace element ratios exhibit high values relative to the primitive mantle. The La/Nb vs. Ba/Nb and Nd/Nb vs. Th/Nb systematics align with High-Density Fluids (HDFs) in fibrous diamonds, suggesting a High-Mg carbonatitic composition (cf.: [1,4]). Despite density differences (HDFs: high-density vs. hydrous silicic fluid: low-density; [2]), their trace element ratios appear comparable.

Since this fluid is ubiquitous around mineral inclusions, it may facilitate the diffusive loss of incompatible elements (e.g., Pb, Th) from the mineral. This could explain why U-Pb ages of exposed inclusions consistently match kimberlite eruption ages, as the escaping fluid remains unaccounted for [3]. Future geochemical analyses of exposed inclusions from diamonds should consider such an effect.

[1] Krebs et al. (2019), *Lithos* 324–325, 356–370.

[2] Nimis et al. (2016), *Lithos* 260, 384–389.

[3] Smit et al. (2022), *RiMG* 88, 567–636.