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The Origin of Spongy Clinopyroxene – Implications for Incipient Melting in the Cratonic mantle

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Spongy clinopyroxene is a common secondary phase in mantle xenoliths. It is usually observed around the boundaries of the host clinopyroxene in both peridotitic and eclogitic rocks. The exact mechanism for spongy clinopyroxene formation is a matter of debate, with possible causes including: incipient melting as a result of interaction with mantle melts/fluids, incipient melting driven by decompression melting, or formation at depth through dissolution of the host clinopyroxene due to interaction with the mantle fluids [1]. Near-surface alteration and the presence of low-pressure secondary phases with spongy clinopyroxene pose significant obstacles in allowing us to unravel its formation mechanism in mantle xenoliths [2].

We address this problem by studying six eclogitic clinopyroxene inclusions in Cullinan and Urals diamonds that have cores with primary compositions and rims with variable proportions of spongy clinopyroxene. Compared to the primary homogeneous omphacite cores, spongy clinopyroxene is depleted in Na and Al (Na_2O: 0.9–4.2 wt%, Al_2O_3: 3.2–11.1 wt%) and enriched in Mg and Ca (MgO: 8.2–18.5 wt%, CaO: 13.9–23.7 wt%). The spongy regions exhibit pronounced chemical heterogeneity. Raman spectroscopy reveals that the volatile compositions of the primary cores and spongy rims are nearly identical in each inclusion, suggesting that the formation of spongy textures did not involve significant volatile influx or outflux. pMELTS modelling suggests the spongy clinopyroxene rims equilibrated with the primary clinopyroxene cores at pressures of 0.5–2.5 GPa (mainly 1-2 GPa) and temperatures of 1050–1300°C, indicating decompression melting of primary clinopyroxene at shallow upper mantle or even crustal pressures. This is supported by the thermobarometry [3]. The modelled melt compositions associated with each inclusion are felsic and Na-rich.

We conclude that the spongy clinopyroxene formed within inclusions in diamond after the host pyroxene was entrapped in diamond and as a result of decompression melting within the inclusion during the diamonds ascent to the surface.

[1] Kiseeva et al., 2017, ChemGeo, 455. [2] Misra et al., 2004, CMP, 146. [3] Putirka, 2008, Minerals, Inclusions and Volcanic Processes, 69.