No evidence of diffusive homogenisation of carbon isotopes in Yakutian diamonds

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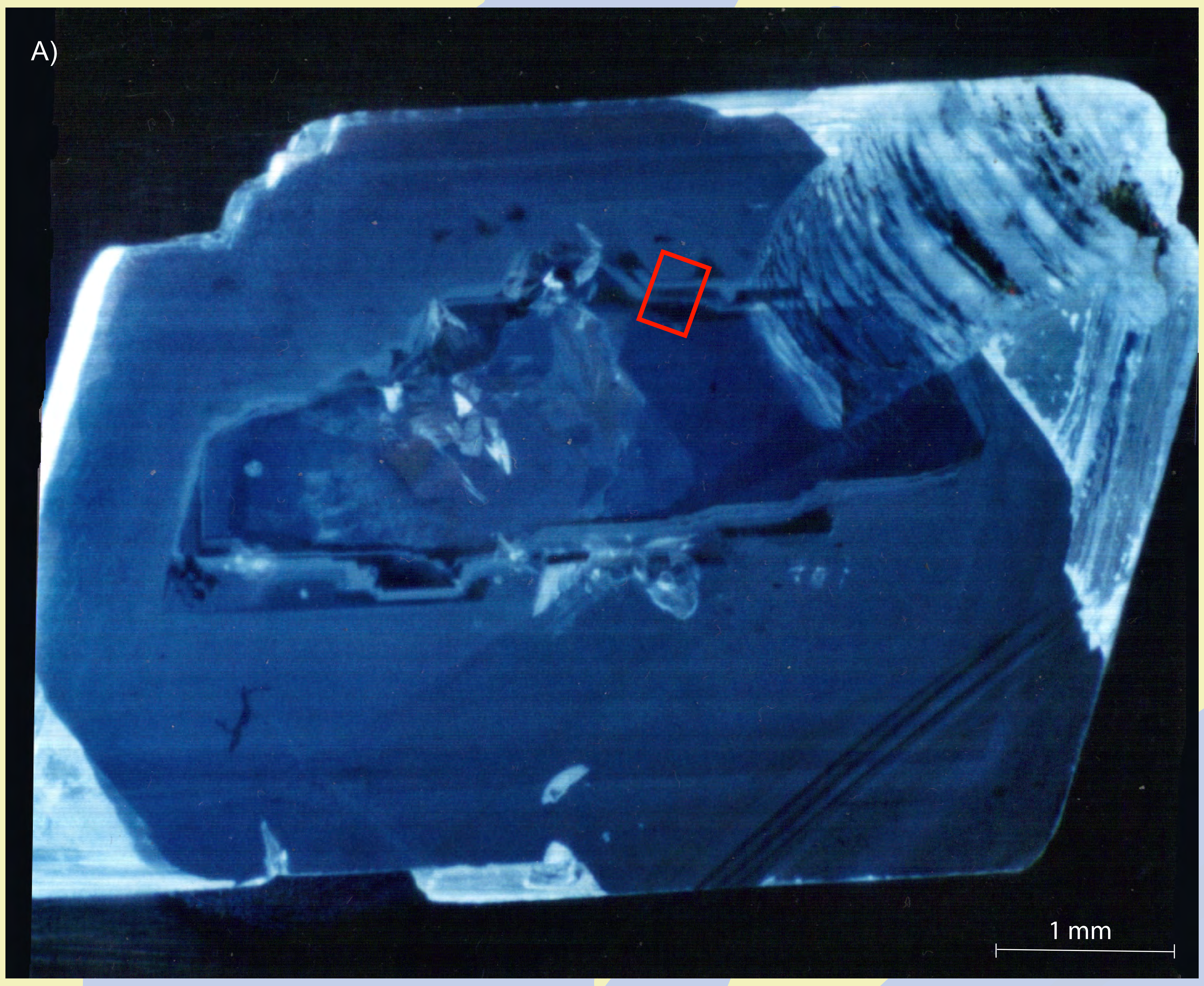
C isotopes of diamonds are potentially useful in establishing the source and temporal evolution of C-bearing fluids in the mantle. Complex growth forms revealed by CL images indicate that many diamonds grew under varying conditions. However, using C isotopes to probe the evolutionary history recorded in successive growth bands is only of use if there is no diffusive equilibration at the μm scale.

Little information is available about carbon diffusion. Harte et al. (1999) suggested that diffusion potentially homogenises C in diamonds due to their long residence in the mantle. Hauri et al. (2002) and Bulanova et al. (2002), however, argued that diffusion was insufficient to equilibrate C in Yakutian diamonds at the 50 μm scale. Diffusion data of Koga et al. (2003) predicts at 1100 °C no homogenisation at 1 μm scale within 1 Ga.

Here we report SIMS data with high spatial resolution (<5 μm, spot size 20 μm) that allows *in situ* analyses of $\delta^{13}C$ at the level of the growth zones. Variation in $\delta^{13}C$ in excess of 1‰ (SIMS reproducibility ±0.2‰) is found between successive growth bands in 5 of the 11 Yakutian crystals studied to date. Detailed traverses across contacts reveal a step-function in $\delta^{13}C$.



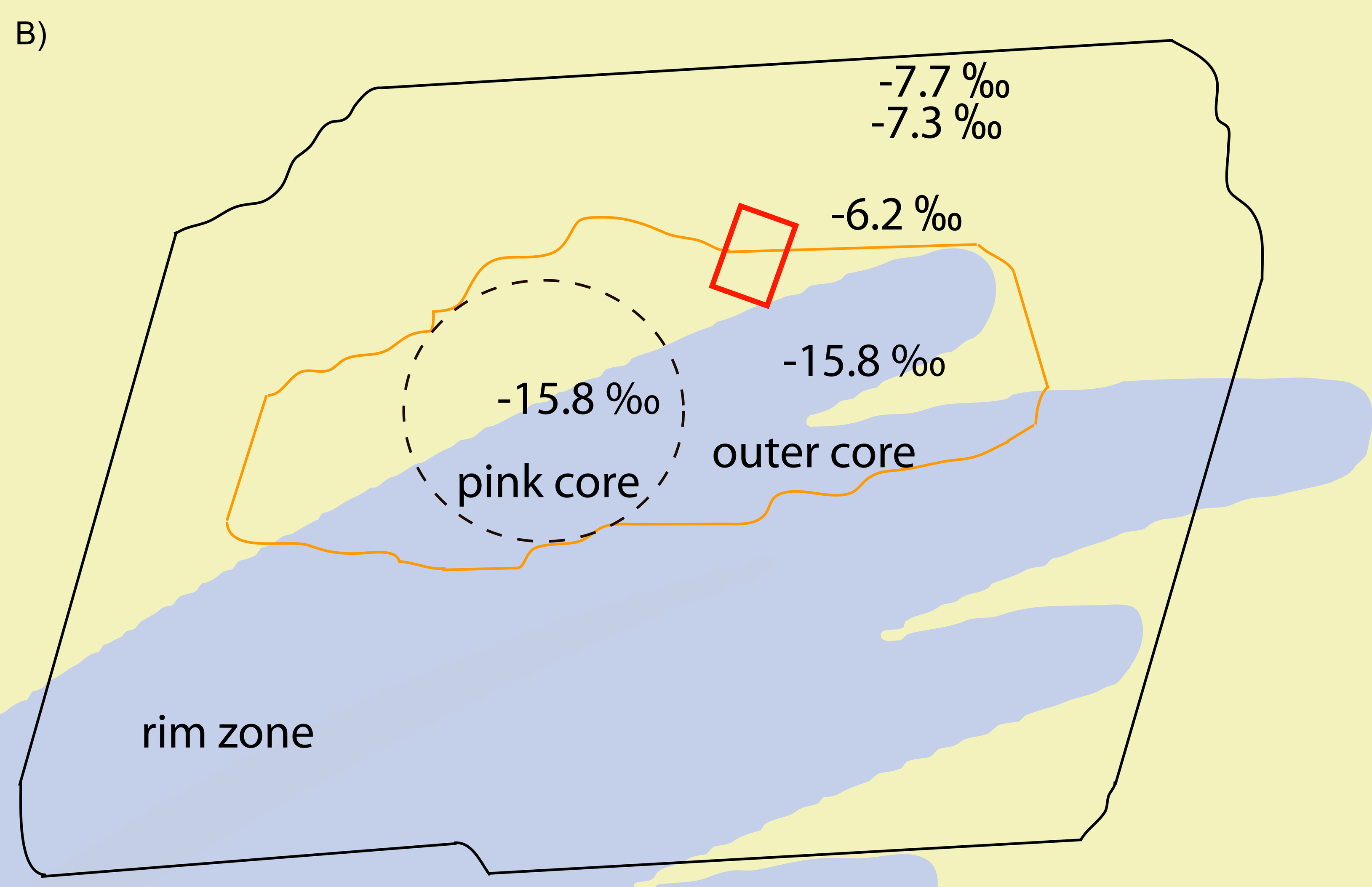
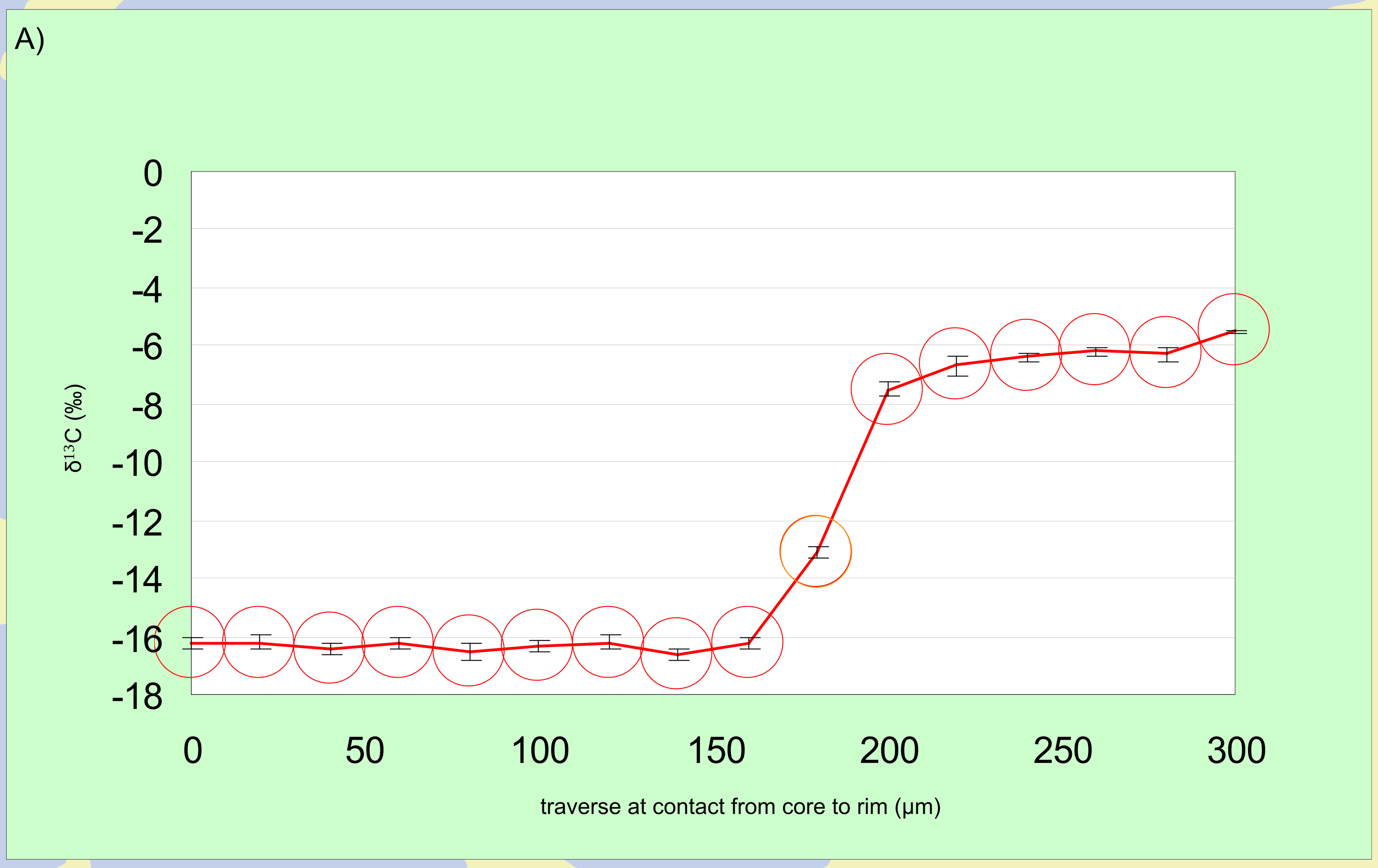


Fig.1A/B. *CL image of diamond 1703 from Mir pipe, Siberia. Two distinct areas exist; an elongated, octahedral core zone which is resorbed (its pink core is off-centre), and an octahedral rim that displays stepped growth (Bulanova et al. 1999). Carbon isotopes record 10‰ difference between core and rim zone.*

Fig.2A. *Traverse at a 20° angle crossing the core-rim contact displays a large change for carbon isotopes, and no gradual change. Several successive probe pits sample the same individual growth band. Spot size and spacing are ~20 μm, so the pits are effectively sampling every 5 μm perpendicular to the growth bands (see fig* ***2B****). Hence, there is no resolvable diffusive exchange between the successive growth bands at 5 μm scale. At this very high precision and fine scale, the -13‰ analysis in the middle of the traverse does not imply diffusion at the 5 μm scale. From image* ***2B*** *it is clear that this analysis samples both sides of the sharp core-rim contact. The core area is homogeneous for C isotopes, while* $\delta^{13}C$ *in the rim area becomes heavier by 2‰ over 100 μm.*
B. *SEM CL image, which shows the position of the ion probe pits (see inset fig* ***1****). A second traverse at ~45° angle to the growth zones can also be seen. Modern, vertical running cracks in the diamond plate cause distortion of the CL image on the bottom-hand side.*



Conclusion:

We therefore conclude that C isotope diffusion is non-existent at the 5 μm scale and that $\delta^{13}C$ variations in successive growth bands do record information about the composition of the C-bearing fluids that formed diamonds.

References:

Bulanova, G.P. et al., 1999. Nature of eclogitic diamonds from Yakutian kimberlites: evidence from isotopic composition and chemistry of inclusions. Proceedings of the VIIth international kimberlite conference., 57-65. Bulanova, G.P. et al., 2002. Chemical Geology, 188, 105-123. Harte, B. et al., 1999. Mineralogical Magazine, 63, 829-856. Hauri, E.H. et al., 2002. Chemical Geology, 185, 149-163. Koga, K.T. et al., 2003. Diffusive relaxation of carbon and nitrogen isotope heterogeneity in diamond: a new thermochronometer. Physics of the Earth and Planetary Interiors, 139, 35-43.