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# Depth of formation of super-deep diamonds: Raman barometry of $CaSiO_3$-walstromite inclusions

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## ABSTRACT

"Super-deep" diamonds are thought to have a sub-lithospheric origin (i.e., below ~300 km depth) because some of the mineral phases entrapped within them as inclusions are considered to be the products of retrograde transformation from lower-mantle or transition-zone precursors. $CaSiO_3$-walstromite, the most abundant Ca-bearing mineral inclusion found in super-deep diamonds, is believed to derive from $CaSiO_3$-perovskite, which is stable only below ~600 km depth, although its real depth of origin is controversial. The remnant pressure ($P_{inc}$) retained by an inclusion, combined with the thermoelastic parameters of the mineral inclusion and the diamond host, allows calculation of the entrapment pressure of the diamond-inclusion pair. Raman spectroscopy, together with X-ray diffraction, is the most commonly used method for measuring the $P_{inc}$ without damaging the diamond host.

In the present study we provide, for the first time, a calibration curve to determine the $P_{inc}$ of a $CaSiO_3$-walstromite inclusion by means of Raman spectroscopy without breaking the diamond. To do so, we performed high-pressure micro-Raman investigations on a $CaSiO_3$-walstromite crystal under hydrostatic stress conditions within a diamond-anvil cell. We additionally calculated the Raman spectrum of $CaSiO_3$-walstromite by ab initio methods both under hydrostatic and non-hydrostatic stress conditions to avoid misinterpretation of the results caused by the possible presence of deviatoric stresses causing anomalous shift of $CaSiO_3$-walstromite Raman peaks. Last, we applied single-inclusion elastic barometry to estimate the minimum entrapment pressure of a $CaSiO_3$-walstromite inclusion trapped in a natural diamond, which is ~9 GPa (~260 km) at 1800 K. These results suggest that the diamond investigated is certainly sub-lithospheric and endorse the hypothesis that the presence of $CaSiO_3$-walstromite is a strong indication of super-deep origin.

**Keywords:** Diamond, inclusion, $CaSiO_3$-walstromite, micro-Raman spectroscopy, ab initio methods, elastic geobarometry