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Mantle transition zone lithologies revealed from majorite inclusions in diamonds

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The Earth's mantle Transition Zone (MTZ) is the depth interval between two major seismic discontinuities at 410 and 660 km. Some diamonds containing majorite garnet inclusions are thought to have originated in the MTZ. Majoritic garnet can form as a result of two types of substitution mechanisms. One can be expressed as $2Al^{3+} = Si^{4+} + M^{2+}$ where M is a 2+ cation such as Mg, Fe, Ca or Mn. This represents the dissolution of pyroxene components such as enstatite into garnet and results in some Si cations having octahedral co-ordination. A second mechanism is expressed as $M^{2+} + Al^{3+} = Na^{+} + Si^{4+}$ and represents solution of jadeite-rich pyroxene into garnet, leading to formation of the Na-rich garnet component Na2MgSi5O12. Examination of the compositions of the majorite garnet diamond inclusion suite and comparison with ultra-high pressure experimental data where bulk compositions are known, indicates that the majority of the inclusions formed neither in pure basic (i.e. eclogitic) nor in ultrabasic lithologies, but in fact crystallized from a range of intermediate "metapyroxenitic" compositions. Given the dominance of the metapyroxenite-type amongst the world-wide majorite diamond inclusion suite and their inferred syngenetic origin, we suggest that a significant fraction of metapyroxenite is present within the MTZ and is important in the diamond-forming process. From mineral chemical and carbon isotope features, we infer a crustal origin for metapyroxenites in the MTZ.