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Abiotic Polycyclic Aromatic Hydrocarbons in Melt Inclusions of a Mantle Xenolith from Tahiti, part of the Society Hotspot Track

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The abiotic formation of organic matter (OM) in the Earth's mantle has been proposed since the 1870s [1]. High-pressure and high-temperature experiments and theoretical studies have demonstrated that simple hydrocarbons polymerize into more complex OM [2]. In this context, polycyclic aromatic hydrocarbons (PAHs) detected in xenocrysts from kimberlite pipes are of particular interest [3]. Although such PAHs are interpreted to have an abiotic origin, their distribution in the mantle and formation processes remain poorly understood.

Here, we report melt inclusions containing PAHs within a clinopyroxene (Cpx) grain from a spinel harzburgite xenolith collected on Tahiti, part of the Society hotspot track. Elemental analyses using energy-dispersive spectroscopy (EDS) revealed that the host Cpx grain has lower Ti and Al contents and higher Mg# than other Cpx grains in the same sample. Our X-ray nano-computed tomography (XnCT) analysis revealed that the inclusions consist of silicate glass, base-metal sulfides, platinum-group minerals, and C-O-H phases. The presence of PAHs within the C-O-H phases was consistently confirmed by Raman microscopy, wide-field fluorescence microscopy, and X-ray absorption near-edge spectroscopy (XANES). Furthermore, XANES analyses demonstrated that these PAHs contain few aliphatic chains or functional groups and coexist with CO and CO_2 in the C-O-H phases.

The detected PAHs are unlikely to be contaminants, as their signals are exclusively observed within the inclusions. The elemental composition of the host Cpx grain supports its deeper origin [4]. Reduced species, such as PAHs and CO are present in the C-O-H phases, indicating that they were trapped under reducing conditions in the deeper regions of the upper mantle [5]. We propose that aromatization of simple hydrocarbons occurred in the C-O-H phases, abiotically forming PAHs under high P-T conditions in the upper mantle. Our discovery suggests the widespread presence of PAHs in the sub-oceanic upper mantle.

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