

## **The structure and distribution of carbon in 3.5 Ga Apex chert: Implications for the biogenicity of Earth's oldest putative microfossils**

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### **ABSTRACT**

The oldest putative microfossils on Earth occur in the 3.5 Ga Apex chert of the Warrawoona Group, Western Australia. We have analyzed disseminated interstitial carbon found within Apex chert using transmission electron microscopy (TEM) and electron energy loss spectroscopy (EELS) to address the controversy regarding its state of structural disorder. We found that the carbonaceous material is structurally amorphous, with no evidence of graphitization, and contains aromatic domains, most likely as polyaromatic ring structures, similar to preserved kerogen in bona fide microfossils. In addition, amorphous carbonaceous material occurs as a grain boundary phase between quartz crystals and within fluid inclusions in quartz crystals, indicating that hydrocarbons moved through the chert during crystallization and hydrothermal alteration. The results suggest that the carbonaceous material is similar in structure to microfossil kerogen, implying the microbe-like features within Apex chert are also microfossils. However, this kerogen-like material may also be produced abiotically via Fischer-Tropsch-type (FTT) synthesis reactions in an ancient hydrothermal vent.

**Keywords:** Geomicrobiology, microfossil, crystal structure, kerogen, Apex chert, Fischer-Tropsch, carbon, electron microscopy, EELS