POSSIBLE ABIOTIC FORMATION OF KEROGEN-LIKE CARBON IN THE STRELLEY POOL CHERT.

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Introduction: Determining the earliest *bona fide* fossil evidence of living organisms on Earth is an important baseline for understanding how life evolves and predicting where life may have evolved elsewhere in the universe. However, making the distinction between biogenic and abiotic features can be problematic, especially in Archean rocks such as the 3.45 Ga Strelley Pool Chert and the 3.46 Ga Apex cherts. Centimeter-scale, conical, laminated structures are found in several locations throughout the Strelley Pool Chert and are morphologically similar to *Conophyton* group stromatolites [1-2]. However, the lack of microfossils associated with these stromatolites and other morphological arguments have led to questions regarding the biogenicity of these structures [3-4]. It has been suggested that the stromatolitic structures are located near ancient hydrothermal vents and cone building is influenced by mixing hydrothermal fluids and seawater [5]. Although this model of hydrothermal control has been implied for at least one stromatolite locality [5], a correlation between stromatolite occurrences and hydrothermal veins has not yet been shown.

The black chert in these veins is rich in carbonaceous material, but the origin of this carbon is unknown. Proponents of the hydrothermal model for the Strelley Pool stromatolites suggest that this carbonaceous material formed via Fischer-Tropsch-type (FTT) synthesis reactions [5], but a biogenic origin for this material is also possible.

Materials and Methods: Black chert samples from the dike system below one of the stromatolite occurrences within the Strelley Pool Chert [5] were crushed and embedded into sulfur droplets, then sectioned in a microtome at either 90 nm or 200 nm.

Samples were analyzed first in the scanning-transmission x-ray microscope (STXM) on the X1A1 beamline at the National Synchrotron Light Source and carbon x-ray absorption near-edge structure spectroscopy (XANES) was performed. The same samples were then analyzed in the transmission electron microscope (TEM) at the Center for Solid State Science at Arizona State University. In the TEM, higher resolution images were taken of the same carbonaceous particles analyzed in the STXM and carbon electron energy-loss spectroscopy (EELS) was performed.

Results: Carbonaceous material within the Strelley Pool Chert is distributed along quartz grain boundaries as thin films, similar to the distribution of Gunflint kerogen [6] and carbonaceous material in the Apex chert [7]. These films are coherent and can form long strings or thin sheets (depending on section thickness) when separated from the chert matrix (Fig. 1).

Carbon XANES spectra of Strelley Pool carbonaceous material is virtually identical to that of Gunflint kerogen and shows peaks at 285 eV (aromatic bonds), 287 eV (aliphatic bonds or phenol groups), and 288.5 eV (carbonyl groups), but no graphite peak at 292 eV (Fig. 2). Spectra of FTT carbon [8] show an aromatic peak and an intense carbonyl peak (Fig. 2a).

Carbon EELS spectra of Strelley Pool carbonaceous material show a significant aromatic peak (285 eV) but no graphite peak at 292 eV (Fig. 3b). The peaks at 287 eV and 288.5 eV are not resolvable with EELS. Spectra of FTT carbon are similar, but with the slight appearance of a carbonyl peak, indicating a large abundance of C=O functional groups.

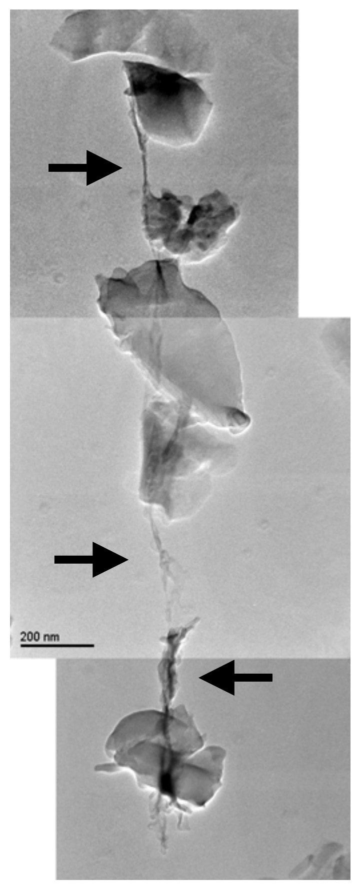

Figure 1: TEM image of kerogen-like carbonaceous material (arrows) attached to several quartz grains. Scale bar is 200 nm.

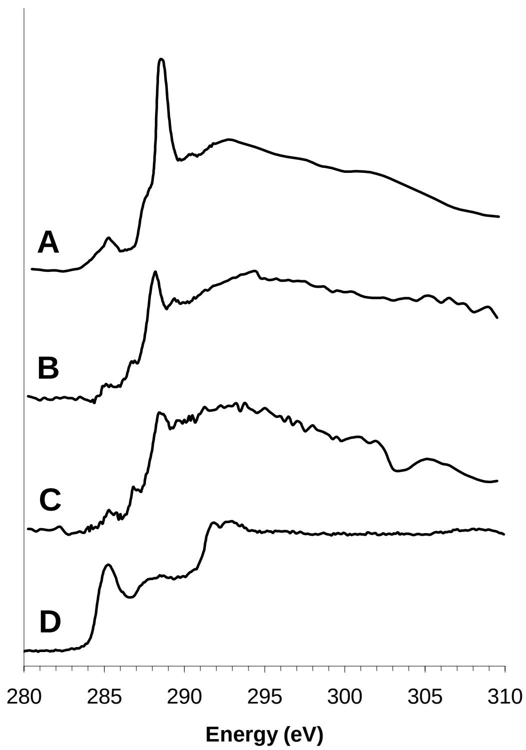

Figure 2: Carbon XANES of (A) FTT carbon, (B) Strelley Pool carbonaceous material, (C) Gunflint kerogen, and (D) graphite (from Flynn *et al.*, unpublished).

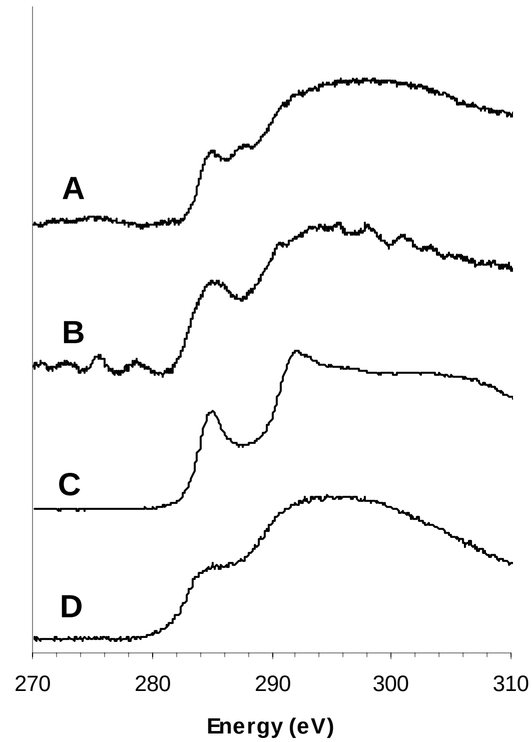

Figure 3: Carbon EELS of (A) FTT carbon, (B) Strelley Pool carbonaceous material, (C) graphite, and (D) amorphous carbon.

Discussion: Comparison of Strelley Pool carbonaceous material with Gunflint kerogen, graphite, and amorphous carbon indicates that it is a kerogen-like material that is largely amorphous and ungraphitized, and contains abundant aromatic carbon and carbonyl groups. FTT carbon is distinct from this material because of its high abundance of carbonyl and lack of phenol groups. However, carbonization during diagenesis may devolatilize FTT carbons, driving off oxygen and transferring some from carbonyl groups in aliphatic chains to phenol groups attached to more stable polyaromatic domains. These processes may transform abiotic FTT carbon into a mature, kerogen-like carbonaceous material [9]. Due to its similarity to Gunflint kerogen, the carbon in the Strelley Pool Chert veins is most likely biogenic, although an abiotic origin cannot be ruled out.

FTT reactions may play an important role in the emergence of living organisms in the Archean as a source of hydrocarbon building blocks for biogenic molecules and/or precursor molecules for simple cellular functions. In this way, the potential hydrothermal controls on Strelley Pool stromatolitic structures may simply be a source of food and materials for a healthy microbial community.

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