Multimodal Mass Spectrometry Imaging (MSI) of Archean and Jurassic Geologic Samples

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Abstract

Current geochemical analytical techniques such as gas chromatography–mass spectrometry (GC–MS and GĆGC–MS) can effectively determine the composition and structure of the organic biosignatures within a sample but cannot resolve the spatial distribution of organic biosignatures within rocks or sediments. The spatial distribution can be used to determine the character of the organic biosignatures [1], which can be indigenous (deposited with host rocks), non–indigenous (incorporated after deposition via fluid migration), or contaminant. Determining the character of organic biosignatures is critical for ancient samples [2] and will be critical if organics are observed in samples returned from Mars [3].

Fs–LDPI–MS has the ability to map organic compounds across the surface of samples at 2 – 10 μm lateral resolution. Furthermore, fs–LDPI–MS can be used to carry out multiple analyses in the same location for micron–scale analysis of previously buried material [4]. We used fs–LDPI–MS to examine a ~164 million year old organic–rich mudstone from SW England (14.2 wt. % total organic carbon) [5] and determined the spatial distribution of likely indigenous components buried below potentially contaminated surface layers.

We then used ToF–SIMS to re–analyze the mudstone to directly compare ToF–SIMS to fs–LDPI–MS datasets, and to analyze a series of ~2.7 billion year old geologic samples from Timmins, ON, CA [6]. Ref. [6] previously analyzed the Archean samples and observed a series of archaeal biomarkers, as well as hopanes and steranes. Using ToF–SIMS analysis, we were able to detect hopanes and steranes in the mudstone

samples, but not in the Archean samples indicating that the hopanes and steranes are most likely contaminants in the Archean samples. We also did not observe the archaeal biomarkers; however, this may be from the lack of molecular ion preservation during ToF-SIMS.

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