Domain-level classification of fossil and extant prokaryotes using micro-FTIR spectroscopy

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Precambrian microfossils show carbonaceous cellular structure, which sometimes resemble in shape and size cyanobacteria and other prokaryotes (e.g. Schopf, 1992; Knoll, 2003). Morphological taxonomy of these minute, simple and more or less degraded fossils is, however, not enough to determine their precise phylogenetic positions. Here we report microscopic Fourier Transform Infrared (micro-FTIR) spectroscopic observations of extant and fossil prokaryotes in order to obtain taxon-specific chemical signature from Precambrian microfossils. In the previous study, we performed micro-FTIR spectroscopy of well-preserved prokaryotic fossils in stromatolitic cherts from the ~850 Ma Bitter Springs Formation (Igisu et al., 2006) and ~1900 Ma Gunflint Formation together with 8 species of extant prokaryotes (Igisu et al., submitted). All the IR absorbance spectra of these fossil and extant prokaryotes show aliphatic CH moieties (~2960 cm^{-1} band due to end-methyl CH_3, and ~2925 cm^{-1} band due to chain-methylene CH_2). We found the aliphatic CH_3/CH_2 absorbance ratios ($R_{3/2}$) of fossilized cell would reflect chemical composition of its precursor membrane lipid, thus could be a useful new indicator for distinguishing domains Bacteria and Archaea for fossil and extant prokaryotes. However, several samples of prokaryotic whole cell and only a few samples of bacterial lipid have been analyzed. In this presentation, we show more systematic measurements of extant Archaea as well as Bacteria. The results show that both domains' $R_{3/2}$ values of whole cells and lipids are approximately constant, and so that $R_{3/2}$ value can be a useful indicator for classifying extant prokaryotes, while further study on $R_{3/2}$ values of fossil prokaryotes is needed.