Compound-specific isotope analysis of DOC in landfill Leachate

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In an attempt to better characterize the biogeochemical evolution of DOC in leachate, and to develop biogeochemical signatures for the origin of DOC in groundwater, we have developed a new approach focusing on the compound specific ^{13}C analysis of DOC. Samples were collected from the Trail Road Landfill site is located about 25 km to the west of the city of Ottawa in Canada, along with field measurements (Eh, pH, EC, TDS, DO, and T). High Performance Liquid Chromatograph (HPLC) is used to separate organic components into fractions. A Total Inorganic/Organic Carbon (TIC/TOC) Analyzer with He carrier gas then measures the DOC concentration and advects the sample to a Delta^{plus} continuous-flow −IRMS for $\delta^{13}C$ measurement. The HPLC fraction collector was used to collect dissolved organic compounds, classified by chromatograph peaks and their column retention times. Although each of these instruments individually is used in some laboratories, this is the first time that fraction-separated DOC compounds have been measured with a TIC/TOC analyser interfaced with IRMS. This represents a new operational system and a significant contribution to analytical technology. In addition, the isotopic characterization of each DOC component will be the first compound-specific isotope analyses of DOC in landfill leachate, which has never been attempted, and represents new knowledge.

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The oldest known sediments on Earth: Implications for exobiology

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What do we search for and how do we interpret data bearing on the appearance of the first life? What are the obvious pitfalls in interpreting the complex crustal history of the oldest rocks here or on any other planet? Without a clear understanding of geological relationships among outcrops and without geochronology or structural maps to guide sample collection, return missions from ancient planetary surfaces (e.g. Mars) will always face enormous obstacles. The oldest terrestrial rocks provide a medium for testing hypotheses to be used in the search for life elsewhere. They shed light on the timing and nature of the emergence of a biosphere on Earth-like planets, clarify when conditions became suitable for life and potentially provide a means for bridging what is known about the origin of life viz. molecular phylogenetic analyses and the preserved geochemical record.

As a case in point, isotopically light carbon found in >3.8 Ga metasediments from Akilia (island) and the Isua Supracrustal Belt, West Greenland, is suggestive of biological activity. This implies that metabolically sophisticated life had arisen prior to the end of intense meteoritic bombardments (~3.85 Ga) of the inner solar system. This inference has been challenged on the basis that: (i) the interpretation of zircon geochronology that that the crosscutting granitoid sheet which establishes the minimum age of an Akilia metasedimentary enclave as >3.8 Ga, is incorrect, and (ii) the Akilia Fe-rich quartzite enclave hosting the earliest proposed chemical fossils of life is instead a “metamorphosed (ultramafic) igneous differentiate”. The second objection would preclude the presence of biosignatures from the pre-3.8 Ga rock record.

Age relations on Akilia have been studied using U-Pb age depth-profiles in zircons from three separate cross-cutting tonalites, thereby refining assessments of the minimum age of the supracrustals. Zircon cores have compositions consistent with crystallization from the host tonalites and thus their magmatic age is 3.83±0.01 Ga; this establishes a minimum age of the surface hydrosphere and putative evidence for life at that time. Opx + grunerite common to meta-BIFs overprint the Akilia sediments. All trace element and stable isotopic data (PGEs, $\delta^{13}C$, $\delta^{18}O$, $\Delta^{33}S$) obtained thus far and new structural studies guiding the geochemistry (Manning et al., this meeting) instead support a primary sedimentary origin for the Akilia rocks hosting evidence for early life.