Life detection strategy for subglacial Lake Vostok, Antarctica: Lessons for Jovian moon Europa

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Bacterial ^{16}S ribosomal gene analysis guarded by criteria for trace DNA analysis and Ancient DNA research testifies for the very low biomass in lake ice from giant subglacial Lake Vostok buried beneath 4-km thick East Antarctic ice sheet. The lake ice seems to be essentially germ-free indicating that the water body should also be hosting a highly sparse life, if any. Therefore the life detection strategy for Lake Vostok must consider a high chance of forward-contamination.

For the Lake Vostok and similar icy environments a special set of indexing contaminant criteria were developed which allowed recognizing most findings as contaminants. The current way to avoid contamination appears to use stringent decontamination procedures and clean room facilities along with comprehensive biological controls including establishment of contemporary contaminant database as a prerequisite to identify and categorize sources of contaminants. More challenge would be to advance cleanliness and sterilization approaches and procedures in order to achieve the level of cleanliness appropriate for tools exploring icy environments like Lake Vostok.

Thus, the life detection strategy for (sub)glacial environments on Earth or Jovian's Europa should consider: (i) stringent ice decontamination procedures to meet chemistry and trace DNA analysis standards, (ii) certification of various environments in contact with ice samples for biological content, (iii) appropriate methods to uncover not only Earthly known life, (iv) verification of findings through their possible metabolic profiles as deduced from environment features and (v) repetition at an independent laboratory.

Multi-isotope approaches for identification of metal contamination sources in environmental systems

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Recent work aimed at determining the sources of metal contamination in the environment have benefited from our improved understanding of metal stable isotope biogeochemistry, but have largely used single isotope systems in combination with other chemical parameters. We are attempting to combine the information derived from multiple related stable isotope systems into robust "multi-tracer" techniques for contaminant source identification, and focus here on two different approaches. In the first, we have used Zn and Cd stable isotopes together to identify the sources of these metals in dust samples collected in an urban setting. Zn and Cd share many geochemical characteristics (e.g., charge, chemical affinity), but likewise have important differences (e.g., melting point, partitioning behavior) that result in differences in isotopic composition (i.e., $\delta^{66/64}$Zn, $\delta^{114/110}$Cd) and distribution (i.e., Cd/Zn) among potential contaminant sources. When viewed in $\delta^{66/64}$Zn-$\delta^{114/110}$Cd-Cd/Zn space, our data implicate vehicle exhaust, waste incineration and metal refinery dust as the primary sources of Zn and Cd in the dust samples, and argue against an important role for coal combustion, fuel oil and natural gas by-products.

In the second approach, we are developing analytical techniques to measure the oxygen isotope composition of dissolved chromate (CrO_4^{2-}) in order to use Cr and O isotope systematics together in a manner analogous to the nitrate 'N-O isotope' method. Our results confirm that oxygen in CrO_4^{2-} and water do not exchange significantly even at temperatures up to 150°C, and thus that extended CrO_4^{2-} residence time in water will not change the primary source signature. In addition, CrO_4^{2-} can be successfully isolated from natural water samples using ion exchange and anion precipitation techniques to remove most other chemical constituents, followed by thermal decomposition to eliminate nitrate from the matrix. We are currently measuring CrO_4^{2-} isotopes in water samples from a contaminated site in southern California in order to test the utility of this novel multi-tracer approach.