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Towards an online ramped oxidation approach for thermal dissection and serial radiocarbon measurement of complex organic matter

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Radiocarbon (^{14}C) measurements provide a powerful tool to deconvolute sources and dynamics of organic matter in the environment. However, interpretation of conventional bulk-level ^{14}C data is challenging due to the myriad components comprising organic matter in soils and sediments. Thermally ramped oxidation provides one approach for overcoming this limitation, and involves subjecting a sample to gradually increasing temperatures, serially oxidizing the OC to CO_2. Collected over prescribed temperature ranges ('thermal fractions'), this CO_2 is then analyzed for ^{14}C content using accelerator mass spectrometry (AMS). While effective, current ramped oxidation methods are mostly 'offline', involving manual collection and subsequent AMS analysis of evolved CO_2, hindering sample throughput and reproducibility.

Here, we introduce a compact, online ramped oxidation (ORO) setup in which CO_2 from discrete thermal fractions is directly collected and measured for ^{14}C by AMS equipped with a gas ion source. The setup comprises two modules: (i) an ORO unit with two sequential furnaces - the first, ramped from room temperature to 900 °C, holds the sample; the second, maintained at 900 °C, includes a catalyst ensuring complete oxidation to CO_2; and (ii) a dual-trap interface (DTI) collection unit with two parallel molecular sieve traps alternately collecting and releasing CO_2 from a given fraction for direct injection into the AMS.

Preliminary results indicate reproducible data, evident in both thermograms and $F^{14}C$ results. Analysis of natural reference samples reveals that measured ^{14}C values and their associated uncertainties align with those reported in the literature using conventional “off-line” ramped oxidation methods, affirming the utility of the new ORO-DTI-AMS setup.

Our goal is to apply this new method for comprehensive investigation of a range of natural samples, with a particular focus on the improved understanding of the fate of OC held in permafrost soils in the context of on-going climate and carbon cycle change in high latitude ecosystems.