Dating the collapse of the Scandinavian Ice Sheet using CH_4-derived carbonate crusts from the Barents Sea

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Assessment of the potential impact of past CH_4 discharge from CH_4 hydrate reservoirs into the atmosphere is hindered by the lack of robust age constraints on the timing of such fluxes. Authigenic carbonates formed in shallow sediments can be related to CH_4 fluxes to the ocean-atmosphere via stable isotope analyses and can be dated by using U-daughter decay (e.g., Teichert *et al*.., 2003) affording the opportunity to constrain the absolute timing and estimate the rates of CH_4 release.

CH_4-derived carbonate crusts exhibiting characteristic ^{13}C-depleted isotopic signatures were collected from several seepage sites of the Barents Sea. The U-Th dating results of early generation aragonite cementing sandy and gravelly sediments constrain the main event of CH_4 discharge and crust formation to a time interval between c. 14 and 11 ka, continuing until c. 9 ka constrained by late stage cavity filling aragonite. These U-Th dates indicate that the carbonate crust formation in the Barents Sea was coincident with the deglaciation of the area and collapse of the Scandinavian Ice Sheet. The CH_4 flux for the carbonate crust formation was likely provided by the dissociation of CH_4 hydrates that extensively formed in underlying sediments during the last glacial period (Chand *et al*.., 2012), but became unstable due to depressuring effects of retreating ice sheet and related isostatic rebound. Ice core records from Greenland and Antarctica demonstrate two CH_4 concentration peaks at ca. 15-13 ka and 11-8 ka, overlapping with the crust formation episode. Such temporal coincidence implies the involvement of destabilised, sediment hosted CH_4 hydrates influencing atmospheric CH_4 and global climate during the last degalciation.

[1] Chand, S., *et al*.., 2012, Earth and Planetary Science Letters, v. 331-332, p.305-314. [2] Teichert, B. M. A., *et al*.., 2003, Geochimica et Cosmochimica Acta, v. 67, p. 3845-3857.

Coupled isotopic and textural evidence for the biogenicity of 3.4 Gyrs old cell-like structures

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The oldest possible morphological evidence for life are 3.4-3.5 Gyr old. Distinguishing geochemical biosignatures in organic matter preserved in such ancient rocks remains difficult due to alteration by deep burial and to the abundance of hydrothermal systems that could have produced abiogenic organics. Microbial morphologies are in general simple and, especially when degraded, can be difficult to distinguish from migrated hydrocarbons precipitated along grain boundaries of variable shapes. Abundant cell-like organic microstructures have been recently reported in the 3.4 Gyr old Strelley Pool Formation from Western Australia. We measured carbon isotope ratios and H/C in situ (with a 15 μm spot) in these organic microstructures using Secondary Ion Mass Spectrometry (SIMS) and characterized the structure of organic matter using Raman spectromicroscopy. Coordinated Raman spectromicroscopy and SIMS carbon isotope measurements distinguished the indigenous cell-like structures and kerogen from late migrated bitumen. SIMS revealed carbon isotopic and H/C heterogeneities between spherical and lenticular cell-like structures and kerogen clots, and internal heterogeneties in lenticular structures. Heterogeneities can be explained by selective diagenetic preservation of the distinct isotopic fractionations inherited from different precursor biomolecules. These results support the interpretation of biogenicity of morphologically cellular structures in the Strelley Pool Formation.

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