Oxygen and the photodissolution of shallow coastal suspended sediments and phytoplankton detritus

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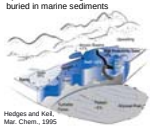
Background

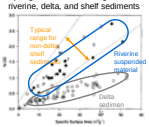
- River delta sediments account for ~44% of organic carbon (OC) buried in marine sediments, globally. (Hedges and Keil 1995). (A, upper right)
- However, deltaic sediments have lower surface-area normalized OC loadings than suspended riverine and non-deltaic shelf sediments (Keil *et al* 1997). (B, middle right)
- **"Photodissolution"** of POC from resuspended deltaic sediments is one hypothesis consistent with their relatively lower OC loadings (Mayer *et al* 2006). (C, lower right)
- ***25-40% of POC is dissolved during laboratory irradiations. Typically, 5% is not detected as DOC.***

A) Distribution of organic matter buried in marine sediments



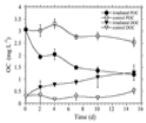
Hedges and Keil, Mar. Chem., 1995

B) Organic carbon loading of riverine, delta, and shelf sediments



Keil, et al, Geochim. Cosmochim. Acta, 1997

C) "Photodissolution" of POC from deltaic sediments during simulated solar irradiation

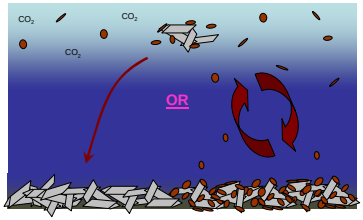


Mayer et al Limnol. Ocean. 2006

Questions

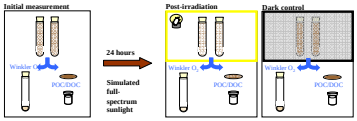
Is photodissolution reversible, once particles settle out of the surface water (right side of schematic, below)?

Is photodissolved POC *photooxidized*, as is dissolved organic carbon (left side of schematic)?



What are impacts on O_2 and nitrogen forms during photodissolution?

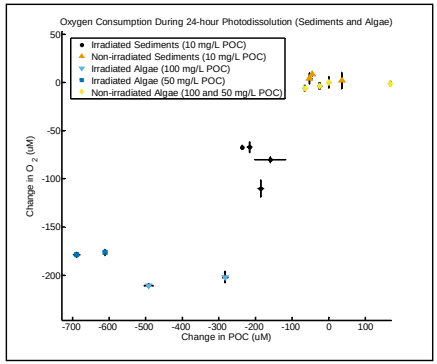
Study Area and Experimental Design

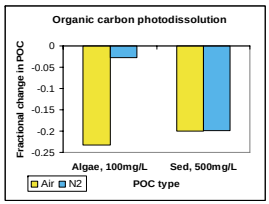


- Suspensions of Atchafalaya bottom sediments and freeze-dried algae (*Tetraselmis* spp., membrane fraction) made up in carbon-free artificial seawater.
- Replicate suspensions were irradiated in a solar simulator or kept in the dark as non-irradiated controls, all at room temperature.
- Suspensions were analyzed for POC, DOC, and dissolved O_2 before and after irradiation.
- To test for effects of microbial degradation followed by irradiation, additional *Tetraselmis* membrane samples were allowed to decay for periods of 2 weeks and 2 months prior to irradiation and analysis as described above. Additional analyses for DON, PN, total acid- and enzymatically-hydrolyzable amino acids (THAA and EHAA), NO_x, and NH_4 were carried out on these samples.

Results and Discussion

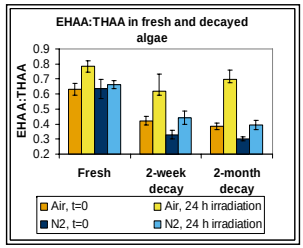
- Sediments at reasonable field concentrations resulted in strong depletions of O_2. For suspensions with the highest initial POC concentrations (algae, 100 mg/L), O_2 levels after 24 h of irradiation were below detection.
- For both algal membrane and Atchafalaya Bay bottom sediments, the photodissolution of POC consumed O_2 at a molar ratio (C:O_2) of about 3:1. This is consistent with the remineralization of 5% of total organic carbon not accounted for after irradiation.

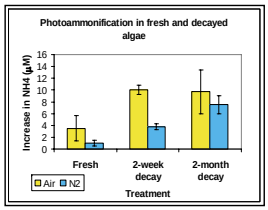




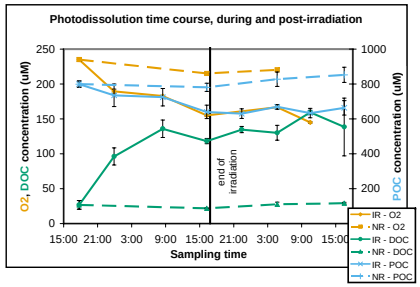
- Algal membrane photodissolution was strongly inhibited in N_2-saturated suspension, but reaction extents were nearly equal for air- and N_2-saturated sediment suspensions.

- The EHAA fraction of THAA decreased during pre-irradiation algal decay. Irradiation then increased access of enzymes to THAA, suggesting that the initial drop was due to protein "encapsulation" by protective material or cross-linking that is especially sensitive to irradiation under O_2.





- Photoammonification occurred during irradiation of fresh and decayed algal membranes, making up 12-18% of total N photodissolution. Production was higher for decayed membranes and under oxic conditions.



- POC, DOC, and O_2 monitored for further 24 h after the end of a 24-h irradiation of sediments exhibited no significant additional dissolution, oxygen consumption, or readsorption, consistent with irreversibility of the photodissolution process.

Conclusions

- O_2 is involved, when present, in the photodissolution of POC from suspended sediments.
- O_2 is likely required for the photodissolution of fresh algal phytodetritus.
- The C:O_2 molar loss ratio is about 3:1, consistent with photo-oxidation of the fraction of photodissolved POC not detected as DOC.
- Irradiation may accelerate N cycling, via enhanced hydrolysis and photoammonification.

References

Hedges JI and RG Keil, 1995. *Mar. Chem.* **49**: 81-115.

Keil RG, et al, 1997. *Geochim. Cosmochim. Acta* **61(7)**: 1507-1511.

Mayer LM, et al, 2006. *Limnol. Oceanogr.* **51(2)**: 1064-1071.

Acknowledgements

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