MEDFLUX: ASSOCIATION OF ORGANIC MATTER WITH BALLAST MINERALS IN SINKING PARTICLES

Lee Cindy [1] *, Armstrong Robert A. [1], Wakeham Stuart G. [2], Peterson Michael L. [3], Cochran J. Kirk [1], Miquel Juan Carlos [4], Masqué Pere [5], Goutx Madeleine [6]

[1] Marine Sciences Research Center, Stony Brook University, Stony Brook, NY, USA, *cindylee@notes.cc.sunysb.edu
[2] Skidaway Institute of Oceanography, Savannah, GA, USA, stuart@skio.peachnet.edu
[3] Department of Oceanography, University of Washington, Seattle, WA, USA, mlpmlp@u.washington.edu
[4] Marine Environment Laboratory, IAEA, Monaco, j.c.miquel@iaea.org
[5] Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Bellaterra, Spain, Pere.Masque@uab.es
[6] Laboratoire de Microbiologie Marine, Campus de Luminy, Marseille, France, goutx@com.univ-mrs.fr

Abstract

Recent evidence points to a relatively constant ratio of organic matter to mineral ballast in particles sinking in the deep ocean. We hypothesize that ballast minerals physically protect a fraction of their associated organic matter, and that this protected OM dominates over the unprotected fraction deeper in the water column. We suggest that the ratio of organic carbon to ballast may be key to predicting variability in export fluxes and sinking velocities of organic carbon as estimated using radiotracers. Using data collected at the DYFAMED site in the western Mediterranean, we present results that bear on these hypotheses.

Keywords: organic mater, ballast minerals, sediment trap, particulate matter

We recently hypothesized that minerals produced by organisms, or introduced into the surface ocean by winds, critically influence carbon export to the deep ocean and sediments (1). Minerals typically constitute more than half the mass of sinking particles, and are important for making less dense organic matter sink (2). Minerals may also protect organic matter from degradation, allowing it to penetrate deeper into the ocean. We demonstrated (a) that ratios of particulate organic carbon to mineral ballast converge to a nearly constant value (~6 wt% OC) at depths >1800 m (1), and (b) that decreases in flux of over two orders of magnitude are attended by minimal changes in bulk organic composition (3). Because these patterns are the hallmark of physical protection, we hypothesize that a substantial fraction of particulate organic matter raining through marine water columns is protectively associated with mineral grains. Thus, the types and amounts of mineral ballast introduced to the surface ocean may be critical, although largely overlooked, determinants of the ocean's ability to take up and store bioactive elements.

Data obtained from the DYFAMED site in the western Mediterranean bear on these hypotheses. Besides our standard in-situ pump, Niskin bottle, and IRS sediment traps, we used for the first time a new conical, free-floating NetTrap, an elutriator, and an IRS trap in the sinking velocity mode. The sinking velocity mode allowed collection of particles with sinking rates from 1-1000 m/d. We measured a large suit of organic and inorganic parameters.

At 200 m, mass fluxes decreased from about 1000 mg/m^2/d in early March to about 10 mg/m^2/d in early July. Sediment traps operated in a "sinking velocity" mode were used to obtain a sinking velocity profile. The IRS valve used to prevent the entrance of swimmers into the trap was rotated once each day to allow particles to fall into the trap. The trap collector cups were then rotated in a time-sequence that allowed us to determine the particle settling rate within the trap. The sorted particles could then be retrieved and subjected to analysis. Fig. 1 shows the mass fluxes at the settling velocities measured. Most material settled at around 200 m/d. Chemical analysis of this material includes organic, inorganic and radiochemical parameters. Fig. 2 shows the results of preliminary analyses of percent organic and inorganic carbon and total nitrogen. The C/N ratio does not change greatly over the velocity profile. However, the %OC, and less so the OC/IC, increases towards the slower settling velocities. Given that much of the mass not represented by OC, IC and TN is due to mineral ballast, these results suggest that the OC/ballast ratio is higher for more slowly settling material. In addition, the fact that %OC increases more than OC/IC at lower settling rates suggests that other materials, e.g., biogenic silica, may be more important ballast than IC at 200m. Further chemical analyses will show whether organic matter composition changes with settling velocity.

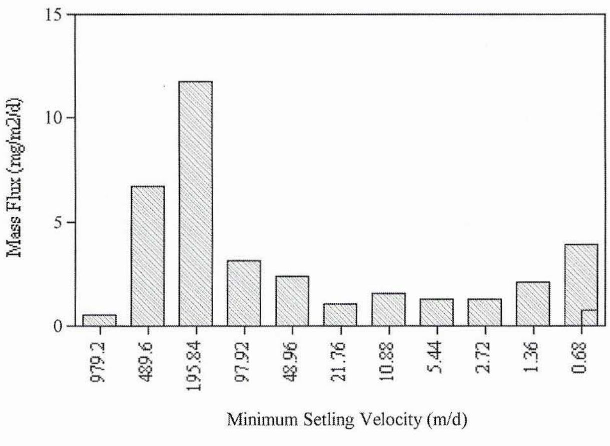

Fig. 1. Mass fluxes at 200 m measured at different settling velocities.

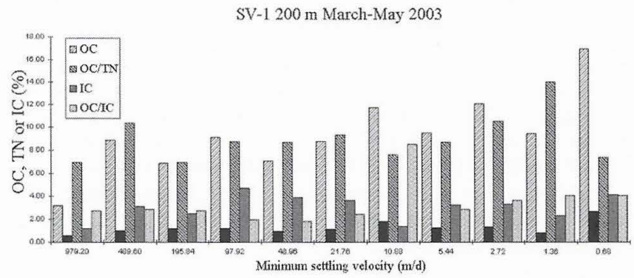

Fig. 2. Organic carbon and total nitrogen (black bars) fluxes, C/N ratio, inorganic carbon flux, and OC/IC ratio at 200 m measured at different settling velocities.

References

1 - Armstrong R.A., Lee C., Hedges J.I., Honjo S., and Wakeham S.G., 2002. A new, mechanistic model for organic carbon fluxes in the ocean, based on the quantitative association of POC with ballast minerals. *Deep-Sea Res. II*, 49: 219-236.

2 - Klaas C., and Archer D.E., 2002. Association of sinking organic matter with various types of mineral ballast in the deep sea: Implications for the rain ratio. *Global Biogeochem. Cycles*, 16: Art. No. 1116.

3 - Hedges J.I., Baldock J.A., Gélinas Y., Lee C., Peterson M.L., and Wakeham S.G., 2001. Evidence for non-selective preservation of organic matter in sinking marine particles. *Nature,* 409: 801-804.