# Benthic $O_2$ fluxes measured by Eddy Covariance in a large flume facility

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### The Eddy Covariance: a new technique to assess sediment-water $O_2$ exchanges over various environments

The Eddy Covariance (EC) is a novel technique used to quantify the sedimentary $O_2$ consumption of marine ecosystems [1]. It measures $O_2$ exchanges at the sediment-water interface over large spatial scales (> 100 $m^2$) without being intrusive or disturbance of the flow field. This new technique has recently been used in various natural environments as tropical lagoon [2], tidal flat [3], river [4] and deep ocean [5] systems.

In autumn 2011, EC deployments were carried out in a 18 m long flume tank (NIOZ Yerseke, The Netherlands) filled with muddy sediment (Figure 1). Based on simultaneous measurements of near-sediment velocities (ADV Vector, *Nortek*) and $O_2$ concentrations (*Unisense* Clark-type microelectrode) at high frequency (64 Hz), $O_2$ exchanges at the sediment-water interface were calculated by EC. These EC fluxes were then compared with values based on microsensor profiling and chamber incubation.

**Figure 1:** The flume Eddy Covariance deployment (Sept. 2011) showing sensor set-up (velocimeter, left and microelectrode, right).

### First results and conclusions

EC $O_2$ fluxes were similar or greater than those obtained by incubation and microsensor profiling, i.e -23.8˜-62.9, -42.2˜-56.0 and -15.8˜-19.5 mmol $m^{-2}$ $d^{-1}$ respectively. EC fluxes varied with flow velocity, sensor depth and upstream location. The deployment of the EC technique in the flume facility allows to investigate various aspects of boundary layer hydrodynamics under controlled conditions.

[1] Berg et al. (2003) *Mar. Ecol. Pro. Ser.* **261**, 75-83. [2] Hume et al. (2011) *Limnol. Oceanogr.* **56**, 86-96. [3] Kuwae et al. (2006) *Mar. Ecol. Pro. Ser.* **307**, 59-68. [4] McGinnis et al. (2008) *Geophys. Res. Lett.* **35**, doi:10.1029/2007GL032747. [5] Berg et al. (2009) *Limnol. Oceanogr. Meth.* **7**, 576-584.

# Theoretical carbon isotope fractionation under deep-earth conditions

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### Introduction

In addition to the major component of mantle carbon, which has $\delta^{13}C$ values of about -5±3‰, some reduced (carbide, hydrocarbons) and neutral (diamond, graphite, dissolved C) carbon compounds from mantle xenoliths and other sources have $\delta^{13}C$ values in the range of -20 to -35‰. Contamination of organic carbons near the Earth surface and the recycling of sedimentary organic matter via subduction zones have often been invoked to explain the depleted $^{13}C$ signatures of these mantle rocks. However an increasing number of studies do not support this scenario. Two other possibilities exist. First, mantle carbon could have been isotopically heterogeneous since the accretion from the solar nebula and the core–mantle segregation in the first 100 My of Earth history. Chondrites, carbonaceous chondrites particularly, which are widely considered to represent primitive undifferentiated materials from which the Earth accreted, have $\delta^{13}C$ values ranging widely from -28 to 0‰. Another possibility is that there exist some mechanisms and processes for large carbon isotope fractionation at high temperatures and pressures. For example, Craig [1] and Deines and Wickman [2] reported *ca*. 12 ‰ differences between graphite and cohenite, $(Fe, Ni, Co)_3C$, from iron meteorites. A recent experimental study by Satish-Kumar *et al*. [3] reported 2.7 - 4.5 ‰ differences between graphite/diamond and FeC melt at 1350 - 2100°C and 5 - 10 GPa.

### Theoretical study

Here, we report our updated reuslts of theoreitcal calcualtions on $^{13}C/^{12}C$ fractionation among major C-bearing materials ($CO_2$, calcite, diamond, graphite, and SiC). Our results show that SiC is depleted in $^{13}C$ realtive to diamond/graphite and calcite even at very high temperautes: 2.5 - 9 ‰ at 1000 - 2000°C. Our results for SiC is consistent with the experimental results for FeC melt [3]. High preussures (>10’s of GPa) under deep-Earth conditions may also affect measurably equilibrium isotope fractionation of C-bearing species [4]. Thus, the recent experimental study and our theoretical calculaitions clealry demonstate that carbides ($Fe_3C$ and SiC) are significatnly depleted in $^{13}C$ at high tmeperatues and pressures. We need to revise and improve our understanding of carbon cycles and associatted isotope fractionation in the deep-Earth.

[1] Craig (1953) *GCA* **3**, 53-92.
[2] Deines and Wickman (1975) *GCA* **39**, 547-557
[3] Satish-Kumar *et al*. (2011) *EPSL* **310**, 340-348.
[4] Polyakov & Kharlashina (1994) *GCA* **58**, 4739-4750.