

Remineralization rate of carbon in sediments north-northwest of Fernandina Island and between  
Isabela and Santiago Islands, Galapagos Islands

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## **Project Summary**

The remineralization rate of carbon in ocean sediments found in the vicinity of the Galapagos Islands will be analyzed and an effort to relate it to the concentration of chlorophyll a in the overlying water column will be made. CTD fluorometer readings and sediment samples will be collected from the R/V Thomas G. Thompson at four sites north of Fernandina Island (expected high levels of chlorophyll a) and three sites in the canyon between Isabela and Santiago Islands (expected low levels of chlorophyll a), and a dissolved oxygen profile for each sample will be obtained using an oxygen microelectrode. Oxygen penetration depths will be converted to amount of carbon remineralization using the Redfield Ratio in an attempt to quantify the flux of carbon from ocean's surface to the seafloor, ultimately resulting in predictions about the movement of CO<sub>2</sub> between the earth's atmosphere and the deep ocean.

## **Introduction**

Quantifying the flux of carbon from the ocean's surface to the sea floor is necessary to predict future levels of atmospheric carbon dioxide (Jahnke et al. 1990). Since the last glacial period, atmospheric CO<sub>2</sub> has increased 85ppm, which is thought to be largely due to the movement of CO<sub>2</sub> between the deep ocean and the atmosphere (Devol and Hartnett 2001). The extent to which CO<sub>2</sub> is absorbed from the atmosphere and subsequently transferred and stored in the ocean is dependent upon (1) photosynthetic carbon fixation in the euphotic zone, (2) transfer of some fraction of this fixed carbon out of the euphotic zone as export production, and (3) permanent carbon burial in marine sediments (Devol and Hartnett 2001). Carbon that is remineralized has the potential to be released back into the atmosphere, while carbon that is stored will not affect atmospheric carbon levels.

Continental margins offer one of the largest sinks of carbon, with more than 90% of all organic carbon burial presently occurring in continental margin sediments, due to the relatively large input of fresher organic matter when compared to deep-sea sediments (Hedges and Keil 1995; Hartnett and Devol 2003). Organic matter delivered and incorporated into marine sediments is mineralized via multiple microbial pathways in which the oxidation of organic carbon is carried out through the reduction of  $O_2$ ,  $NO_3$ , oxides of Mn and Fe, and  $SO_4$  (Thamdrup and Canfield 1996). It has been suggested that oxygen consumption is most important in deep-sea sediments, and that the importance of  $NO_3$  and  $SO_4$  oxides as electron acceptors increases in continental slope and shelf sediments (Murray and Kuivila 1990). Furthermore, Hartnett and Devol (2003) found that in sediments on continental margins at depths greater than 1000m, the largest component of the total carbon oxidation rate was also oxygen.

The Galapagos Islands is one area of the world that exhibits levels of productivity that are higher than average (Torres 2002). Historically, high productivity and high chlorophyll a concentrations are exhibited on the western side of Isabela Island, where the Equatorial Undercurrent brings nutrient-rich water to the surface (Feldman 1986; Martin et al. 1994). Areas that exhibit large amounts of organic matter in the surface waters can potentially result in the transport of a larger amount of organic matter to the seafloor, when compared to areas of low surface organic matter. However, it is important to note that other factors contribute to the distribution of surface-originating organic matter among marine sediments, such as the depth of the water column. As organic matter sinks through the water column, a majority of it is biologically oxidized, resulting in a decreasing carbon rain rate with depth and only a small portion being available for burial in the sediments. Murray and Kuivila (1990) observed a decrease in organic carbon in sediments with increasing distance from the continental margin,

which can be related to depth, in that depth generally increases as distance from the shelf increases. It has been suggested that this relationship determines the quantity and time scale at which carbon is sequestered in the deep ocean (i.e. shallower regeneration depths will result in shorter sequestration times) (Devol and Hartnett 2001). Cai and Sayles (1996) compared oxygen penetration in marine sediments and found that a site at which additional organic material, in the form of sewage, was disposed exhibited a much shallower oxygen penetration depth than those exhibited at uncontaminated sites. These data suggest that areas with higher organic matter deposition will exhibit shallower oxygen penetration through the sediments and therefore higher carbon remineralization rates when compared to areas with lower organic matter deposition.

With this study, I intend to address two main questions, (1) do sediment oxygen profiles and carbon remineralization rates vary among stations, and (2) is there a correlation between these variations and concentrations of chlorophyll a in the overlying water column. Based on the results and observations of previous studies, as discussed above, I expect areas that are relatively high in surface chlorophyll a to exhibit shallower oxygen penetration depths, relatively high levels of organic carbon in the sediments and faster carbon remineralization rates, when compared to areas that are low in surface chlorophyll a concentration. Since the distribution of organic matter in marine sediments is not entirely dependent on the amount of chlorophyll a in the water column directly above it, a relationship among only high chlorophyll a concentration stations will likely not be recognizable. However, I expect there to be some sort of discrepancy between the relationships found at high versus low chlorophyll a concentration areas.

### **Proposed Research**

In order to determine sedimentary carbon remineralization rates, and attempt to compare them among high and low chlorophyll a concentration regions of the Galapagos Islands,

observations will be made from 20-28 January 2006 aboard the R/V Thomas G. Thompson using the shipboard Conductivity-Temperature-Depth (CTD) profiler, and sediment samples will be collected using a Spade box core. Samples will be collected at seven stations (Table 1, Fig. 1). Sediment locations for stations 1-4 were determined using seafloor maps generated from EM120 data (Kurz et al. 2001) and all sample stations were chosen based on the expected availability of sediment and expected surface chlorophyll a concentrations (Martin et al. 1994). The availability of sediment at stations 5-7 is assumed, based on the observation that the region is characterized by a canyon and it is likely that sediments accumulate in it. However, upon arrival at each station, the 3.5 kHz sub-bottom profiler will be utilized to confirm the existence of sediments.

CTD casts will penetrate 500m through the water column. One sediment sample will be taken at each station and will immediately be gently sub-sampled with PVC core liner tubes (3-inch diameter, 7-inch length). Four replicate sub-samples from each box core will be taken in order to obtain an average carbon remineralization rate for sediments at each station. The condition of the sediment-water interface will be noted. A well-preserved interface will be defined as having clear overlying water and intact biological structures (Murray and Kuivila 1990). For the purpose of this proposal, it is assumed that the sediment-water interface of all samples will be preserved. It is important for the interface to remain undisturbed in order to obtain an accurate oxygen-depth profile. If the interface is not maintained, the resulting oxygen profile will provide a maximum range of oxygen concentrations through the sediment, rather than an absolute range. Certain cases in which the sediment-water interface is not preserved using the Spade box core include the over-penetration of the core into extremely soft sediments, in which case the speed of the corer as it penetrates the sediment should be reduced, and the

occurrence of significant amounts of biogenic gases in the sediment, in which case not much can be done to obtain an intact interface due to the effervescing of the gases as the core is brought to the surface.

A polarographic oxygen-needle microelectrode (Fig. 2) will be used to determine the dissolved oxygen profile for sediment samples (Revsbech et al. 1980). Profiles for all sediment samples will be recorded immediately upon retrieval to minimize the effects of transporting the core out of its natural environment, including changes in salinity and atmospheric oxygen supply. A Ag/AgCl electrode will be used as a reference during measurements and an electric potential between the silver reference electrode and the a glass-insulated platinum electrode will be produced via a small black box connected to the electrodes. The electrodes will have been calibrated prior to this experiment using air-saturated seawater (20% O<sub>2</sub>) and nitrogen-purged seawater (0% O<sub>2</sub>). In order for the two electrodes to come into electrical equilibrium, oxygen will be reduced at the platinum cathode and silver will be oxidized at the reference anode. This movement of electrons will produce a current which will be measured with a microvolt ammeter. The microelectrode will be inserted into the core from above with the assistance of a micromanipulator attached to a ring stand. An average current reading will be obtained from the overlying water, which should closely represent the actual oxygen concentration in the water at the seafloor. After defining the average water oxygen concentration, the microelectrode will carefully be lowered to the point where the tip of the microelectrode just touches the sediment surface. A significant deflection in the electrode current should occur at this point, and will be used to confirm that the electrode is in fact at the surface of the sediment. The electrode will be lowered into the core at 0.25mm increments and volt ammeter readings will be recorded at each interval. Probing will continue until the current reading reaches zero or remains constant for four

0.25mm intervals. This value will be called “zero” and will be used to convert obtained current readings to oxygen concentrations by the equation (Nuwer, J. pers. comm.):

$$\frac{(\text{current reading}) - (\text{“zero”})}{(\text{water } [O_2]) - (\text{“zero”})} \times 307.4 = [O_2] \mu\text{mol/kg}$$

The computer program, Basic Profile, will be used to convert oxygen depth profiles to total oxygen consumption in the sediments. Carbon remineralization rates will then be calculated via the Redfield Ratio.

**Proposal Budget**

<b>Item</b>	<b>Unit Cost</b>	<b>Quantity</b>	<b>Supplier</b>	<b>Cost</b>	<b>Effective Cost</b>
R/V T.G. Thompson	\$18,000 / day	2 days	UW Oceanography Class Budget	\$36,000.00	\$0.00
3.5 kHz sub-bottom profiler	included	2 days	Thompson Equipment	\$0.00	\$0.00
CTD	included	2 days	Thompson Equipment	\$0.00	\$0.00
Spade box core	\$45 / day	2 days	Pooled Equipment	\$90.00	\$90.00
Core liner (3-inch)	\$4 / ft	1- 10 ft section	Pooled Equipment	\$40.00	\$40.00
Core caps (3-inch)	\$0.25 / each	18	Pooled Equipment	\$4.50	\$4.50
Polarographic oxygen-needle microelectrode	Donated	2	Keil Lab	\$0.00	\$0.00
Ag/AgCl reference electrode	Donated	2	Keil Lab	\$0.00	\$0.00
Microvolt ammeter	Donated	1	Keil Lab	\$0.00	\$0.00
Micromanipulator	Donated	1	Keil Lab	\$0.00	\$0.00
Ring stand	Donated	1	Keil Lab	\$0.00	\$0.00
				\$36,134.50	\$134.50



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**Tables**

Table 1. Station locations and depths for 20-28 January 2006 research

Station	Latitude (South)	Longitude (West)	Estimated Depth (m)
1	0° 9.2'	91° 53.3'	3250
2	0° 5.7'	91° 50.5'	3100
3	0° 9.7'	91° 42.1'	2450
4	0° 13.6'	91° 36.4'	2450
5	0° 13.0'	91° 1.3'	2300
6	0° 16.0'	91° 1.0'	2000
7	0° 17.0'	91° 0.5'	1800

### **Figure Legends**

Figure 1. Map of the Galapagos Islands with stations to be visited for 20-28 January 2006 research. Negative signs indicate western longitudes and southern latitudes. Map adapted from Kurz et al. (2001).

Figure 2. Diagram of the polarographic oxygen needle-microelectrode that will be used to obtain oxygen profiles for sediment samples.

Figures

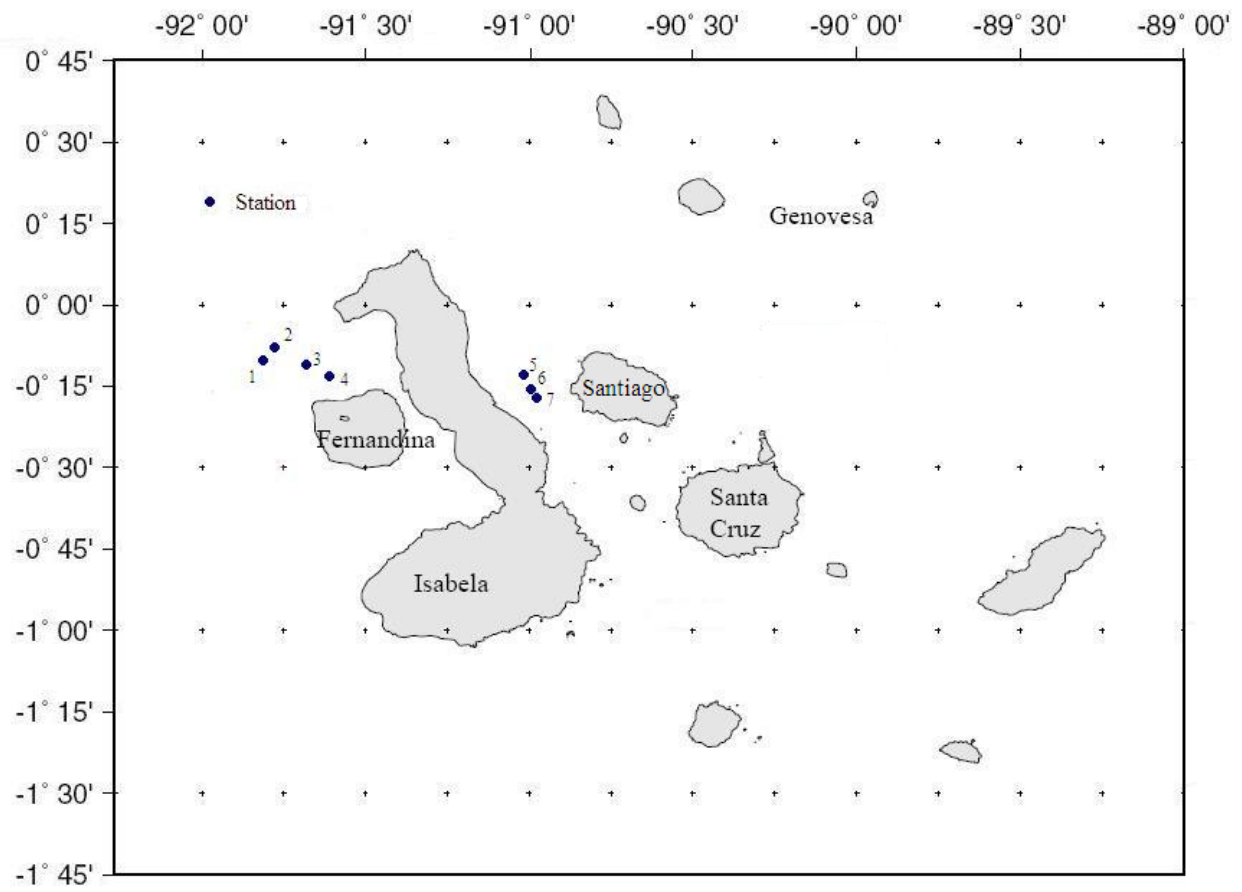


Figure 1.

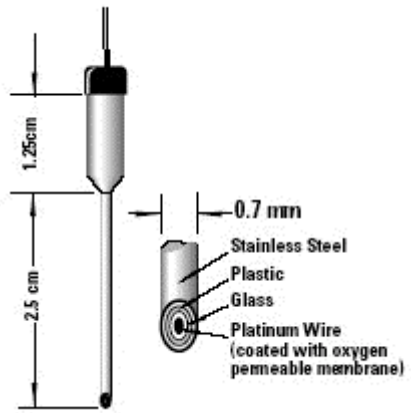


Figure 2.