Acquisition of Stable Carbon Isotope and Other Tracer Data

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Introduction

Two of the objectives within Task II concern the net flux of CO_2 across the air-sea interface and the use of various tracers to identify water masses and their sources. In connection with the first objective, it is generally believed that the ocean plays an important role in sequestering a portion of the CO_2 that is being injected into the atmosphere by fossil fuel burning and deforestation. Relative to the ambient atmospheric $^{13}C/^{12}C$ ratio, the anthropogenic CO_2 is enriched in the lighter isotope, and this has resulted in a decrease of the $\delta^{13}C$ of the atmosphere CO_2 over time. As evidenced by proxy records in corals and sponges, the $\delta^{13}C$ of inorganic carbon dissolved in ocean surface waters has decreased as well, as is expected from the rapid exchange of CO_2 between the atmosphere and the sea. By measuring the contemporary $\delta^{13}C$ distribution and comparing this with proxies of the pre-industrial distribution, we are attempting to establish the pattern of the uptake of anthropogenic CO_2 in the OMEX II area. In the upper water column, the $\delta^{13}C$ measurements are being carried out on a seasonal basis in order to quantify the roles of biological production and air-sea exchange on the isotopic composition.

In addition to $\delta^{13}C$, we will measure the distributions of dissolved methane, $\delta^{18}O$, and radiocarbon to provide tracer information on water mass distribution. Methane and radiocarbon both appear to be transient tracers in that their atmospheric concentrations have changed over time. These measurements have not been conducted in the first year of OMEX II-2. Methane measurements and collections for radiocarbon are planned during the second year on Meteor Cruise M43/2. Samples for $\delta^{18}O$ have already been collected on two cruises as discussed below for carbon isotopes. Since the Leibniz Laboratory is running the $\delta^{13}C$ and $\delta^{18}O$ in batch separately, the oxygen isotopes will be analyzed in Fall, 1998.

Another area of attention in connection with first objective above is the measurement of the partial pressure of CO_2 in surface waters of the OMEX II area and the assessment of net air-sea CO_2 fluxes. Our intercalibration of equilibrator measurements with those of the University of Liege is also planned for cruise M43/2 in January, 1999.

Methods

Water samples for carbon and oxygen isotopic analyses have been collected from two cruises, Belgica 97/14 in summer, 1997, and Poseidon 237/1 in winter, 1998. The analysis is being conducted in the Leibniz Laboratory of the the University of Kiel. Acidification and extraction of the CO_2 for carbon isotopes is conducted on a multiple extraction manifold coupled to a Finnigan-MAT Delta E mass spectrometer. To date, 70% of the Belgica 97/14 samples have been analyzed. In addition, the backlog of samples from Belgica Cruise 95/06, taken during OMEX I, have been completed. The samples remaining from Belgica 97/14 as well as those of Poseidon 237/1 will be analyzed in the next few months.

Results and Discussion (Task II.7.3)

Vertical profiles of $\delta^{13}C$ in the OMEX II area are shown in Figure 1. The samples analyzed so far come from 3 east-west sections along 42°09'N, 42°40'N and 43°00'N. All of these profiles exhibit strong gradients in the upper part of the water column of this area. At 43°N, the shallowest station (123 m depth), exhibits a lower $\delta^{13}C$ value at the surface (1.2‰) than found elsewhere (1.5‰). At this location, the phosphate concentration at the surface (0.3 µmol kg^{-1}) is higher than offshore, possibly indicating an upwelling effect.

A plot of the $\delta^{13}C$ measured on Belgica 97/14 versus phosphate concentrations analyzed on board (University of Brussels) is shown in Figure 2. These results are superimposed on our earlier results from the Goban Spur (49°N) measured during OMEX I. The two sets of data appear to be consistent in that the patterns of $\delta^{13}C$ versus phosphate in both cases agree. The Belgica samples were collected in early summer while the earlier data were collected in winter, 1994. At that time a deep surface mixed layer (300 m) existed in which the phosphate concentration was 0.5 µmol kg^{-1}. The slope of the $\delta^{13}C$ versus phosphate trend in the OMEX II area for phosphate concentrations less than 0.5 µmol kg^{-1} is consistent with that expected of photosynthetic uptake of carbon and phosphate in a closed system. Apparently, finite nutrient concentrations left over from winter vertical mixing are fixed rapidly during the Spring bloom, leading to apparent closed system behavior. This is to be expected since the time scale of restoration of the surface water $\delta^{13}C$ to isotopic equilibrium with the atmospheric is on the order of 10 years, which is much longer than the time elapsed since the bloom event.

The Belgica hydrocasts go down to about 1500 m depth, so that comparison with deeper OMEX I data is not yet possible. However, the data collected so far from the Belgica 97/14 is in accord with a shift in the $\delta^{13}C$ vs. phosphate trend seen at the Goban Spur area. Reconstruction of the $\delta^{13}C$ anomaly due to anthropogenic invasion proceeds in a sense from the bottom up, since anthropogenic effects are not yet seen in the deep water. Therefore the comparsion of deep water samples is important, and these analyses will be forthcoming from the Poseidon 237/1 and Meteor M43/2 cruises.

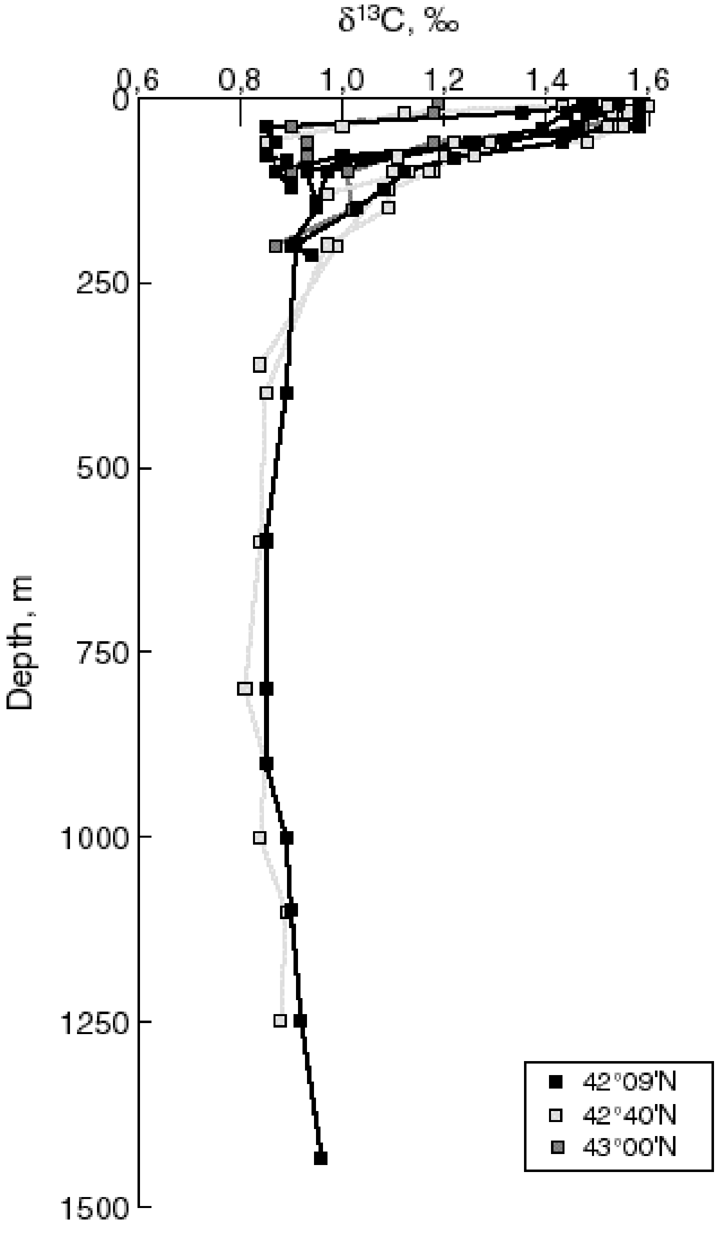

Fig. 1. Station profiles of $\delta^{13}C$ vs. depth. These are grouped according to latitude, as indicated by the different gray tone of the symbols.

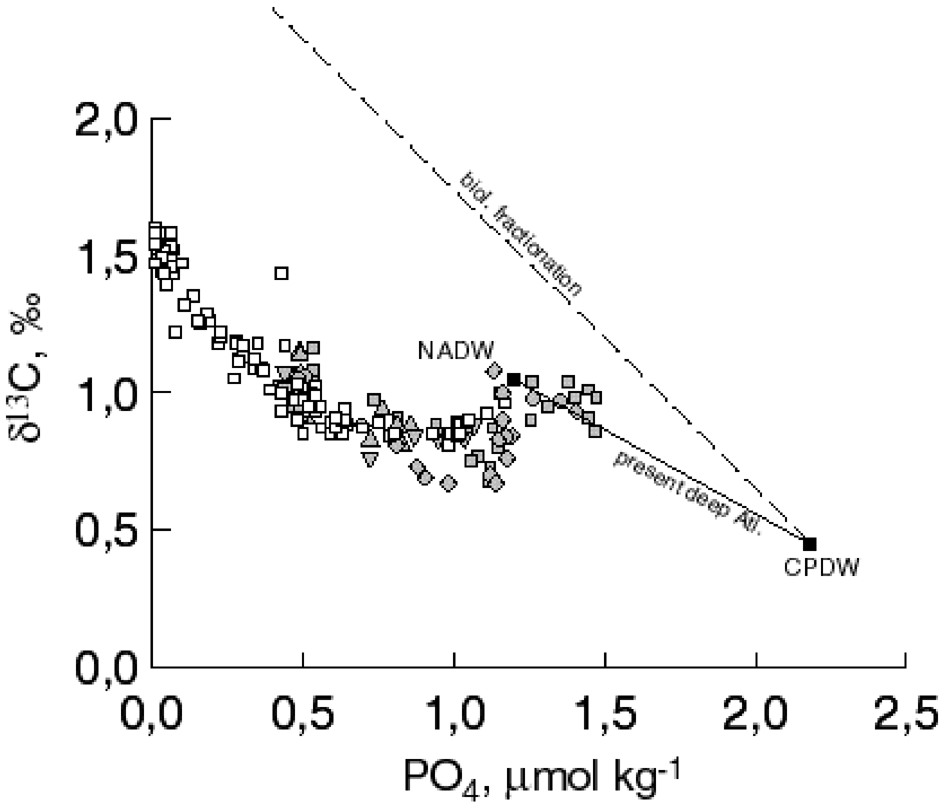

Fig. 2. $\delta^{13}C$ versus dissolved phosphate for Belgica 97-14 (open squares). These data are compared to results from obtained from the Goban Spur during OMEX I (filled symbols in the background). Solid line indicates mixing trend between North Atlantic and Circumpolar deep waters. Dashed line indicates slope expected from biological cycling of carbon and phosphate in a closed system.