Variations in calcite dissolution fluxes in the equatorial Atlantic and Pacific and evaluation of carbonate dissolution due to oxidation of C_{org}

J. Specht
Heidelberger Akademie der Wissenschaften, Im Neuenheimer Feld 366 D-69120 Heidelberg

W. B. Curry
Department of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, USA

D. Hebbeln
Fachbereich Geowissenschaften, Universität Bremen, D-28359 Bremen, Germany

C.-W. Park
A. Mangini
Heidelberger Akademie der Wissenschaften, Im Neuenheimer Feld 366 D-69120 Heidelberg, Germany

To explain the glacial drop of atmospheric CO_2 it is necessary to understand the conditions for $CaCO_3$ dissolution in the oceans. We measured high resolution profiles of $^{230}Th_{ex,cor}$ normalized carbonate in pairs of cores from the Ceara Rise in the Western equatorial Atlantic and from the Ontong Java Plateau in the Western equatorial Pacific. In each case one core (GeoB 1523-1 in the Atlantic and RNDB 74P in the Pacific) is located at a depth above the lysocline and the other core (EW9209 1JPC in the Atlantic and ERDC 127P in the Pacific) at a depth below the lysocline. We then reconstructed (i) the dissolution of $CaCO_3$ due to variations of the depth of the lysocline and (ii) the depth of the sedimentary lysocline during the last 250 kyrs.

In the Atlantic we deduced an increase of the lysocline-induced carbonate dissolution during the glacials and even during some of the cooler interglacial substages. The correlation to the Southern Ocean deep water carbonate preservation index (SOPI) (Howard and Prell, 1994) suggests that during the glacials and during the glacial substages of isotope marine isotope stage five (MIS 5) a reduction in the production of NADW and/or an enhanced northern penetration of AABW occurred. On the Ontong Java Plateau we found a dissolution peak at the onset of MIS 6, as well as enhanced lysocline-induced dissolution in MIS 5 and at the end of the MIS 4.

'Excess' carbonate dissolution takes place at all times on the seafloor even at depths lying above the calcite saturation horizon (Emerson and Bender, 1981). Dissolution has at least two causes. The first one arises from the geochemical environment (e.g. the CO_3^{2-} concentration in the water column) bathing the sediments. The other one is due to the oxidation of organic matter in the sediments, as proposed by Archer and Maier-Reimer (1994).

We evaluated total excess carbonate dissolution in the same way as done by Broecker and Sanyal (1997). In the Atlantic total excess $CaCO_3$ dissolu-

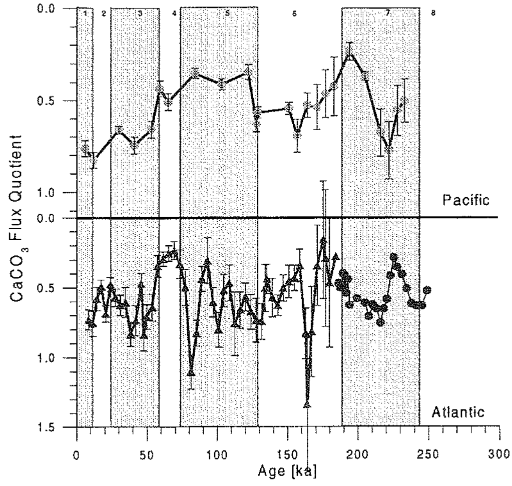

FIG. 1. The quotient of the $^{230}Th_{ex,cor}$ normalized $CaCO_3$ fluxes from the core above the lysocline and in the depth range sensitive to lysocline variations is plotted against age. Peaks indicate a higher lysocline-induced calcite dissolution. The Atlantic profile was completed with concentration quotients (circles) since the flux error became to large due to decreasing $^{230}Th_{ex,cor}$ activities.

tion amounts to about 9 g $CaCO_3$ cm^{-2} for marine MIS 4. In the Pacific we found a total excess $CaCO_3$ dissolution of 9 g $CaCO_3$ cm^{-2} at the boundary MIS 5/4 and 8 g $CaCO_3$ cm^{-2} in the glacial substage 5e. These values are significantly lower than the value of 26 g $CaCO_3$ cm^{-2} reported by Broecker and Sanyal.

Furthermore we were able to distinguish two parts of excess carbonate dissolution. The part of dissolution due to shallowing of the lysocline was determined by subtracting a background dissolution flux from the dissolution flux arising from the shifts in the lysocline depth. The background dissolution flux results from a defined baseline lysocline depth of 3900 m (Ceara Rise) and 3200 m (Ontong Java Plateau) and a weighted depth profile of the respective area. These calculations result in a lysocline induced excess $CaCO_3$ dissolution of about 5 g $CaCO_3$ cm^{-2} for marine MIS 4 in the Atlantic. In the Pacific we found about 4 g $CaCO_3$ cm^{-2} at the end of the MIS 4, 7 g $CaCO_3$ cm^{-2} at the boundary MIS 5/4, 8 g $CaCO_3$ cm^{-2} in the glacial substage 5e and 20 g $CaCO_3$ cm^{-2} at the onset of MIS 6.

Excess dissolution occurring due to the C_{org} oxidation can at maximum amount to the difference between the total excess dissolution and the lysocline-induced excess dissolution. The contribution we found in the equatorial Atlantic during MIS 4 amounts to 4 g $CaCO_3$ cm^{-2} and in the equatorial Pacific to a maximum of 1 g $CaCO_3$ cm^{-2} at the boundary MIS 5/4.

The lysocline-induced excess dissolution as calculated here does not account for a change of the C_{org} rain rate into sediments. We believe that this should be negligible because our core pairs, originate from a close vicinity to each other and probably received nearly the same C_{org} fluxes. Furthermore, the quotient of fluxes of carbonate should cancel out the effects of $CaCO_3$ dissolution due to respiration-CO_2, if the C_{org} oxidation is the same for both depths. However, we cannot exclude that the $CaCO_3$ dissolution by C_{org} oxidation is depth-dependent. In such an hypothetical case is it reasonable to assume that C_{org} oxidation would be more effective at shallower depths where more organic matter and oxygen are available. This would result in an underestimation of the lysocline-induced excess dissolution and even smaller values for dissolution due to the C_{org} oxidation.

We therefore conclude, contrary to the results of Broecker and Sanyal (1997) in the equatorial Pacific, that the dissolution related to the organic matter rain rate is of minor importance.

References

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