

Relationship between carbonate ion concentration in the deep-sea and density of foraminifera shell based on X-ray CT

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The Antarctic ice core records revealed glacial CO₂ concentrations in the atmosphere was ~80 ppm lower than that of during the interglacial periods (Barnola et al., 1987). The mechanism of low atmospheric pCO₂ during the glacial period is one of the most important problems in the field of paleo-climate. Carbon pool in the deep sea is 60 times as large as the atmosphere. Thus, most of paleoclimate scientists consider that the deep-sea must have played a key role in carbon cycles during glacial-interglacial periods. However, there is no broadly accepted evidence. In order to explain the low atmospheric pCO₂ during the glacial period, carbonate ion concentration [CO₃²⁻] in the deep sea water mass must be ~40 micro mol kg⁻¹ lower than that of modern one (Broecker and Peng, 1993).

Oceanic CaCO₃ cycle (CaCO₃ preservation and dissolution) with glacial-interglacial cycle is a key to solve this problem. Carbonate saturation state (Omega) of a particular water sample is

$$\Omega = ([Ca^{2+}][CO_3^{2-}])_{SAMPLE}/K_{sp}$$

[Ca²⁺] of open ocean is constant at glacial-interglacial timescales. Therefore, [CO₃²⁻] is the important factor in determining saturation state. In previous studies, several proxies that aim to reconstruct the past [CO₃²⁻] in the deep-sea were suggested. However, there is no established quantitative proxy for [CO₃²⁻]. Objective of our study is to develop a novel quantitative proxy for past [CO₃²⁻] based on density of foraminiferal shell (micro-plankton with CaCO₃ shell). We used Micro-focus X-ray CT Scanner (MXCT; ScanXmate L080, Tohoku University Museum) to measure density of foraminifera shell accurately. MXCT is a non-destructive research technique which allows investigating internal structure of foraminifera shell in 3D. This enables to evaluate progression of dissolution in the foraminifera shell. Today, this proxy has not been accepted as paleoceanographic method. Thus, in this study, We will develop the MXCT method into a novel quantitative proxy for past [CO₃²⁻] in the deep-sea.

Planktic foraminifera species (*Globigerina bulloides*) from eight sea-surface sediment samples ranging from 1362 to 3135 m water depths were obtained from the western North Pacific. These foraminifera samples were used for shell density measurements by MXCT. In addition, measurement on shell weight by ultra-micro balance (UMT2, Mettler Toledo) and fragmentation ratio of foraminifer shells were performed. In order to understand a relationship between density of foraminifera shell and [CO₃²⁻] in the deep-sea, obtained data were compared with the [CO₃²⁻] in the deep-sea calculated based on chemical analysis in sea-water samples by JAMSTEC Data Search Portal. Our preliminary MXCT results employing planktic foraminifera shells in sediment trap samples (i.e., non-dissolved shells) at Station K2 suggested that density of foraminifera was size dependent. In order to estimate the size effect on shell density, we selected 10 planktic foraminifera shells with similar shell size from each surface sediment sample and measured single shell weight of each 10 shells. As a result, qualitative relationship between the shell weight and [CO₃²⁻] in the deep-sea was shown, supporting a theory that carbonate dissolution is controlled by [CO₃²⁻] in the deep-sea. We will discuss on detailed relationship between foraminifera shell density and [CO₃²⁻] in the deep-sea.

Barnola, J.M. et al., 1987, Nature 329, 408-414.

Broecker and Peng, 1993, Greenhouse Puzzles. Eldigio Press