Data report: bulk sediment organic matter, carbonate, and stable isotope stratigraphy from IODP Expedition 346 Site U1427 (250–530 m CCSF-D_Patched)

Sonja Felder, Andrew C.G. Henderson, Melanie J. Leng, and Hilary J. Sloane

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Abstract

Bulk sedimentary characteristics are presented from Integrated Ocean Drilling Program Site U1427, covering the depths greater than 250 m core composite depth below seafloor (CCSF-D_Patched), which spans the mid-Pleistocene transition. Site U1427 is located in the southern Sea of Japan/East Sea and was drilled during Integrated Ocean Drilling Program Expedition 346. Total organic carbon ranges from 0.5 to 3.1 wt%, total nitrogen ranges from 0.04 to 0.32 wt%, and carbonate (CaCO₃) contents vary between 1.3 and 25.7 wt%. The carbon isotope ratio of organic matter (δ¹³Corg) values range from −24.9‰ to −20‰. There is a broad correspondence between the geochemical parameters and the shipboard color reflectance index (b*), and this relationship becomes more pronounced from ~375 m CCSF-D_Patched upward. The b* index has been used as an indicator of glacial–interglacial cycles at Site U1427. Using this inference, the data suggest reduced marine productivity during glacial and interglacial cycles.

Introduction

This report presents new data of total organic carbon (TOC), total nitrogen (TN), and calcium carbonate (CaCO₃) content as well as the carbon isotope ratio of organic matter (δ¹³Corg) in bulk sediments for the lower 250 m of the Integrated Ocean Drilling Program Site U1427 sediment column. Although studies on the upper ~250 m have previously been published (Black et al., 2018; Gallagher et al., 2018; Sagawa et al., 2018; Saavedra-Pellitero et al., 2019), little has yet been done on the lower cored interval. The lower 250 m encompass the mid-Pleistocene transition, an enigmatic period of Earth’s climate past, during which the periodicity of glacial and interglacial cycles shifted from a 41,000 year frequency to the modern 100,000 year frequency (Shackleton et al., 1976; Pisias and Moore, 1981; Lisiecki and Raymo, 2005).

Site U1427 was cored during Integrated Ocean Drilling Program Expedition 346 (Asian Monsoon) and is located in the Sea of Japan/East Sea at a shallow water depth of about 330 m (Figure F1). Marine productivity in the Sea of Japan/East Sea is mainly controlled by variations in East Asian summer monsoon intensity and glacio-eustatic sea level fluctuations as a result of their influences on nutrient input to the basin (Oba et al., 1991; Tada, 1994; Tada et al., 1999). The main nutrient source to the Sea of Japan/East Sea is thought to be the inflow of the Tsushima Warm Current through the Tsushima Strait in the south of the basin (Figure F1), although local nutrient input cannot be excluded at Site U1427 due to its close proximity to land. Glacio-eustatic sea level influences nutrient input by restricting the inflow of the Tsushima Warm Current at glacial sea level lowstands. During interglacials, nutrient input is high as a result of the unrestricted inflow of the Tsushima Warm Current, but at glacial sea level lowstands, the shallow Tsushima Strait, having a sill water depth of only ~130 m, is nearly dried up, reducing or preventing the inflow of the nutrient-enriched Tsushima Current and leading to reduced marine productivity in the basin (Oba et al., 1991; Tada, 1994; Tada et al., 1999; Tada et al., 2015c). Variations in the East Asian summer monsoon affect productivity by controlling the relative contribution of nutrient-rich waters from the East China Sea to the Tsushima Warm Current, increasing nutrient contents at times of enhanced monsoonal precipitation (Oba et al., 1991; Tada et al., 2015a; Saavedra-Pellitero et al., 2019). These variations in nutrient availability affect primary productivity and proxies recording marine productivity, such as TOC, TN, C/N ratios, δ¹³Corg, and CaCO₃ content.

2 School of Geography, Politics and Sociology, Newcastle University, United Kingdom. Correspondence author: s.felder@ewetel.net
3 British Geological Survey, Nottingham, United Kingdom.
4 School of Biosciences, Nottingham University, United Kingdom.

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Figure F1. Bathymetric map of the Sea of Japan/East Sea and Expedition 346 sites, including Site U1427 (modified from Tada et al., 2015c); major ocean currents (after Inoue, 1989, and Tomczak and Godfrey, 1994); outflow of the Yangtze and Yellow Rivers into the Yellow and East China Seas; and sill depths, including the Tsushima Strait (after Oba et al., 1991; Tada et al., 1999; Lee and Choi, 2015).

The resulting stoichiometric coefficient of 8.33 was used to calculate the CaCO3 content from TIC, assuming all TIC is bound to calcium carbonates (calcite or aragonite):

\[
\text{CaCO}_3 \text{(wt%)} = \left( \frac{\text{TC} - \text{TOC}}{\text{TIC}} \right) \times 8.33 = \text{TIC} \times 8.33. \tag{3}
\]

For completeness, Equation E3 shows the calculation of TIC from total carbon (TC) and TOC (after Bernard et al., 1995).

The data in this study (geochemical data and shipboard b* index) (Tada et al., 2015b) are presented in Table T1. The CCSF-D_Patched depth scale has been used in publications on the upper 250 m of sediment cores at Site U1427 (Black et al., 2018; Gallagher et al., 2018; Itaki et al., 2018; Sagawa et al., 2018; Saavedra-Pellitero et al., 2019; Peterson and Schimmenti, 2020). For reference, Table T1 also contains depth on the core depth below seafloor, Method A (CSF-A) scale (i.e., the depth in meters below seafloor as established on board the ship).

### Results

The TOC, TN, C/N ratios, δ13Corg and CaCO3 data are plotted against shipboard color reflectance index b* (Figure F2; Table T1). The high-resolution b* record was used during Expedition 346 as an indicator for glacials/interglacials. Glacial sediments have lower b* values, whereas interglacial sediments have relatively higher b* values (Tada et al., 2015c). During glacials, low b* coincides with low CaCO3 and TOC contents (Figure F2), indicating reduced marine productivity and corroborating previous studies (Tada et al., 2015c; Black et al., 2018; Gallagher et al., 2018; Sagawa et al., 2018; Saavedra-Pellitero et al., 2019). In addition, glacials are characterized by enhanced contributions of terrigenous organic matter as indicated by lower δ13Corg values (Figure F2). In marine algae, δ13Corg varies with marine productivity via the preferential uptake of 12C, but the δ13Corg values are also influenced by variations in terrigenous organic matter input. In simple terms, marine plankton typically show δ13Corg values between −20‰ and −22‰, and δ13Corg of terrigenous material generally has lower δ13Corg values around −27‰ (e.g., Jasper and Gagosian, 1993; Meyers, 1994). Glacial exposure of shelves and migration of the Yellow/Yangtze River mouths to positions closer to the Tsushima Strait, potentially combined with local riverine input at Site U1427, likely led to the glacial increase in terrigenous contributions to the sediments. In contrast, interglacials are characterized by relatively higher CaCO3, TOC, and δ13Corg values, indicating reduced terrigenous and enhanced marine organic matter contributions to the sediments as a result of enhanced marine productivity (Figure F2).

Intriguingly, the C/N ratios do not always follow the trends and patterns of the above geochemical proxies. In general, C/N ratios of marine algae are lower than 10, and organic matter of land plants typically shows values higher than that (Scheffer and Schachtschabel, 1984; Meyers and Lallier-Vergès, 1999). At Site U1427, C/N ratios vary between ~2 and 16 across the interval 250–530 m CCSF-D_Patched, indicating a mixed marine-terrigenous source of organic matter and corroborating previous studies of the upper 140 m and the shipboard low-resolution data (Black et al., 2018; Tada et al., 2015c). However, interpretation of C/N ratios often differs from the other proxies presented here. C/N ratios tend to be lower during glacials, indicating enhanced marine organic matter and contradicting the interpretation of CaCO3, TOC, and δ13Corg. In two intervals, ~390–320 and ~300–270 m CCSF-D_Patched, C/N ratios become variable, missing a clear glacial–interglacial trend (Figure F2). Vari-
ations in C/N ratios are usually controlled by the relative contributions of marine and terrigenous organic matter; however, in the Sea of Japan/East Sea, an eolian contribution cannot be excluded, and/or, although rarely mentioned, an additional inorganic, clay-bound component of nitrogen may have played a role at Site U1427, complicating the interpretation of C/N ratios (Schubert and Calvert, 2001; Seki et al., 2019).

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Table T1. δ¹³Corg of organic matter (δ¹³Corg), total organic carbon (TOC), total nitrogen (TN), and calcium carbonate (CaCO₃) contents and TOC-TN (C/N) ratios, Site U1427. Download table in CSV format.

References


Figure F2. Total organic carbon (TOC), total nitrogen (TN), C/N ratios, δ¹³Corg and calcium carbonate (CaCO₃) content of sediment samples and shipboard color reflectance index b* against depth (in CCSF-D_Patched). Shaded areas indicate glacials.


