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Organic carbon burial and their implication on sea surface primary productivity in the middle Okinawa Trough over the past 200 ka

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The long-term burial of organic carbon in marginal seas plays a critical role in Earth's carbon cycle and climate change. However, the mechanism of organic carbon (OC) burial in the Okinawa Trough (OT) during glacial-interglacial timescales remains unclear. In this study, we analyzed the foraminiferal carbon isotopes, total organic carbon (TOC), and δ^{13}C-TOC over the past 200 ka in core Z1 collected in the central OT. We aimed to reveal the history of OC burial in the middle Okinawa Trough during the past 200 ka, and we combined our findings with relevant paleoenvironmental indices to reveal underlying mechanisms. We found reduced surface primary productivity during MIS 6, which may indicate changes in the pathways of the Kuroshio Current (KC). Furthermore, we observed decoupling between high TOC flux and low OC burial during glacial periods. We proposed that the dilution effect caused by the high sedimentation rate and poor OC preservation during the glacial period resulted in the low TOC content. Ventilation of the North Pacific Intermediate Water (NPIW) regulated the redox conditions of the intermediate water in the Okinawa Trough. Additionally, the intensified Kuroshio Current during interglacial phases led to water column stratification, creating reducing conditions in the bottom water and facilitating improved OC preservation. Subsequently, the enhanced water column oxygenation resulting from the oxygen carried by the intensified glacial NPIW weakened the burial of OC. This study sheds new light on our understanding of the carbon cycle in marginal seas on a glacial-interglacial timescale.

KEYWORDS

organic carbon burial, carbon cycle, foraminiferal carbon isotope, primary productivity, North Pacific Intermediate Water, Kuroshio Current

Highlights

- Different burial regimes of organic carbon were identified on glacial-interglacial time scales in the middle Okinawa Trough
- Sea level fluctuation and terrigenous input influenced productivity during the glacial-interglacial cycle in the middle Okinawa Trough
- Organic carbon burial in the middle Okinawa Trough is primarily regulated by mineralization processes within the water column

1 Introduction

Long-term buried organic carbon in marine sediments has a significant impact on the Earth's carbon cycle at the orbital and millennial scales by regulating atmospheric CO_2 levels and thus affecting the global climate (Sigman & Boyle, 2000; Clark et al., 2006; Burdige, 2007; Cartapanis et al., 2016; Keil, 2017). Cartapanis et al. (2016) collected organic carbon (OC) data from hundreds of sediment cores around the world and found that during the last interglacial-glacial cycle (~150 ka), the glacial accumulation rates of OC were consistently higher than the interglacial accumulation rates (Cartapanis et al., 2016). The enhanced export productivity, improved transfer of organic matter and better preservation of organic matter contributed to an increase in organic carbon burial during glacial periods (Cartapanis et al., 2016). Elevated burial of organic carbon due to high productivity and better preservation conditions was also observed in glacial sediments collected from the low-latitude Atlantic, the eastern equatorial Pacific and the Southern Ocean (Bradtmiller et al., 2010; Martínez-García et al., 2014; Cartapanis et al., 2016).

However, high export productivity does not necessarily lead to high OC burial, decoupling between these factors might exist in some regions, and long-term OC burial may be related to other environmental factors. As reported by Li et al. (2018), the main factors controlling the increase in OC burial in the glacial period over the past 91 ka were the Kuroshio Current (KC) intrusion and sea level change in the central OT, which counteracted the low export productivity. To better understand the mechanism of OC burial in global marine sediments and its relation with the carbon cycle, more OC preservation records from different regions and over longer time scales need to be collected.

Approximately 50% of the marginal seas are located in the Western Pacific (Li et al., 2018). As the main depositional areas of terrigenous matter, marginal seas have enormous potential for marine carbon sequestration and as carbon sinks (Bauer et al., 2013; Shao et al., 2016; Dai et al., 2022). The Okinawa Trough is adjacent to the continental shelf of the East China Sea (ECS), and its unique location and topography make it a deposition center in the ECS. Many large rivers flow into the ECS, which causes the trough to receive tremendous detrital matter from East Asia. Compared with the continental shelf, the deeper water and slower sedimentation rate of the OT are conducive to preserving long-scale paleoenvironmental information, providing high-resolution sedimentary records for the reconstruction of tectonic evolution, hydrological environmental changes, and global climate change during the Quaternary (Shinjo et al., 1999; Jian et al., 2000; Kao et al., 2005; Kao et al., 2006; Chang et al., 2009; Ujiié et al., 2016; Li et al., 2017; Zhao et al., 2021; Zhang et al., 2022).

The North Pacific has consistently been a hotspot for millennium- and orbital-scale carbon cycle research (Zhao et al., 2021). Numerous studies have reported the factors influencing organic carbon burial in the OT, such as productivity (Chang et al., 2009; Shao et al., 2016; Li et al., 2017), hydrological conditions (Kao et al., 2005; Ujiié et al., 2016; Li et al., 2018) and redox change (Dou et al., 2015; Zou et al., 2020; Zhao et al., 2021). However, the time scales of these studies are mostly concentrated in the period from the last glacial period to the Holocene, and the burial mechanism of OC in the OT over longer time scales remains an unknown. In this study, we analyzed the carbon isotopes of planktonic foraminifera, TOC and δ^{13}C-TOC generated from site Z1 located in the middle OT (Figure 1) and combined these data with previously published δ^{13}C values of benthic foraminifera and $CaCO_3$ content to explore the impact of mineralization processes and ventilation on OC burial over the past 200 ka.

2 Materials and methods

The sediment core Z1 (28°49′N, 127°20′E) used in this study was collected from the middle continental slope of the Okinawa Trough at a water depth of 940 m in 2015 (Figure 1). The lithology of this 60-meter-long core is relatively uniform, and it is basically composed of clay silt (Dou et al., 2021). The age model of Z1 over the past 200 ka (Figure 2A) was established by Dou et al. (2021) based on planktonic foraminiferal AMS^{14}C dating and by comparing the δ^{18}O record obtained from benthic foraminifera with the global benthic stack LR04. The core was subsampled at intervals of 20 cm, and 280 sediment samples were obtained. The $CaCO_3$ content, carbon, and oxygen isotopes of benthic foraminifera were determined in Dou et al. (2021).

For TOC% analysis, excess 1 N HCl was added to sediment samples to remove inorganic carbon. After mixing, the samples were placed in a 60°C water bath with shaking and left undisturbed for 3 h after the reaction. The acid in the sample was then decanted after centrifugation, and the sample was washed three times with deionized water. The samples were then dried in a 40°C oven, weighed and ground into powder. $TOC\%_{measure}$ was analyzed using a Vario EL III elemental analyzer (Elementar, Germany), and the measurement errors were all within the standard deviation of<0.05%. TOC% was further calculated by the $TOC\%_{measure}$ and $CaCO_3$% published in Dou et al. (2021), as shown in Equation 1.

$$TOC\% = TOC\%_{measure} * (100\% - CaCO_3\%) \qquad (1)$$

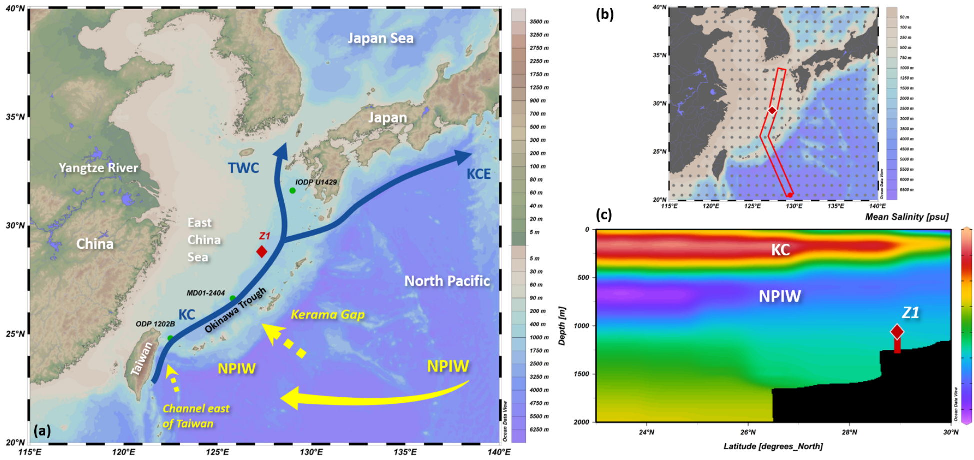

FIGURE 1
Major circulation system of the Okinawa Trough. **(A)** The location of site Z1 (red diamond) and referenced cores (green circle), including IODP U1429 (Zhao et al., 2021), MD01-2404 (Li et al., 2018) and ODP 1202B (Dou et al., 2015). KC: Kuroshio Current; NPIW: North Pacific Intermediate Water; TWC: Tsushima Warm Current; KCE: Kuroshio Current Extension. The solid blue line with an arrow indicates the path of the KC. The solid yellow line with an arrow indicates the spreading path of NPIW from the northeast Pacific. The dashed line with an arrow represents the two passages through which the NPIW enters the Okinawa Trough. **(B)** The selected section for mean salinity. The red diamond represents site Z1. **(C)** The salinity in the upper 2000 m along the selected section in **(B)**. Salinity data were collected from ODV: World Ocean Atlas 2018 (awi.de). Figures were generated by Ocean Data View software (Schlitzer, 2021) and with reference to Figure 1 in Zhao et al. (2021).

In the δ^{13}C-TOC test, the above acidified samples were used, and analysis was performed with a Thermo Deltaplus XL stable isotope mass spectrometer with a test accuracy of ±0.15‰ (VPDB).

For foraminiferal carbon isotope analysis, approximately 10 shells of *Globigerinoides ruber* (*G. ruber*) were selected from each sample and tested using a MAT 253 stable isotope mass spectrometer (Finnigan, Germany). The test accuracy was determined based on the National Calcium Carbonate Standard (GBW04405) and International Standard (NBS19), and sample pretreatment and testing were completed at the Third Institute of Oceanography, Ministry of Natural Resources.

3 Results

3.1 Variability in TOC% and δ^{13}C-TOC

The TOC% of core Z1 ranges between 0.93-3.76% (Figure 2C) since Marine Isotope Stage 6 (MIS 6), with an average value of 2.01%. The average TOC% during glacial (MIS 2-4 and MIS 6) and interglacial periods (MIS 1 and MIS 5) is 2.53% and 1.85%, respectively. The variation in TOC% is similar to that of $CaCO_3$% (Dou et al., 2021); both present a higher value during interglacial periods and a lower value during glacial periods (Figure 3D).

The δ^{13}C-TOC of core Z1 ranges from -29.6 ‰ to -18.0 ‰ (Figure 2D), with an average ratio of -21.8 ‰. The lowest δ^{13}C-TOC value occurred at the MIS 5/4 boundary, which is in agreement with regional methane emissions (Dou et al., 2021), and the δ^{13}C value at other times was relatively stable.

3.2 Carbon isotope of foraminifera

The δ^{13}C of planktonic foraminifera *G. ruber* ($\delta^{13}C_{G.\ ruber}$) in Z1 ranges from -6.03 ‰ to 2.80 ‰, with an average value of 0.24 ‰ (Figure 3A). The mean $\delta^{13}C_{G.\ ruber}$ratio during glacial and interglacial periods are 0.64 ‰ and -0.14 ‰, respectively. During the glacial periods, $\delta^{13}C_{G.\ ruber}$ was depleted and greatly fluctuated (Figure 3D).

The carbon isotope data of benthic foraminifera *C. wullerstorfi* were published in Dou et al. (2021). The $\delta^{13}C_{C.\ The\ Wullerstorfi}$ value ranges from -2.99 ‰ to 0.88 ‰, with an average value of -0.07‰ (Figure 3B). The general trend was similar to $\delta^{13}C_{G.\ ruber}$, and the δ^{13}C signal was negative during the glacial period (Dou et al., 2021). The δ^{13}C difference between planktonic foraminifera (*G. ruber*) and benthic foraminifera (*C. wullerstorfi*) reflects changes in surface productivity (Jian et al., 2001; Tian et al., 2017). The isotope difference between surface and bottom water was calculated as Equation 2:

$$\Delta\delta^{13}C_{P-B} = \delta^{13}C_{G.\ Ruber} - \delta^{13}C_{C.\ Wullerstorfi} \tag{2}$$

The $\Delta\delta^{13}C_{P-B}$ ranges from -6.16 ‰ to 2.07 ‰, with an average value of 0.31 ‰ (Figure 3C). The lowest $\Delta\delta^{13}C_{P-B}$ occurs during MIS 6. The average $\Delta\delta^{13}C_{P-B}$ is -0.18% during MIS 6, compared with the average ratio of 0.77% during MIS 1-5. The dramatic depletion in $\delta^{13}C_{G.\ ruber}$ during MIS 6 are also recorded in adjacent IODP site U1429 (Vats et al., 2021). Furthermore, the $\Delta\delta^{13}C_{P-B}$ ratio remains stable during MIS 1-5, and no glacial-interglacial cycle is identified.

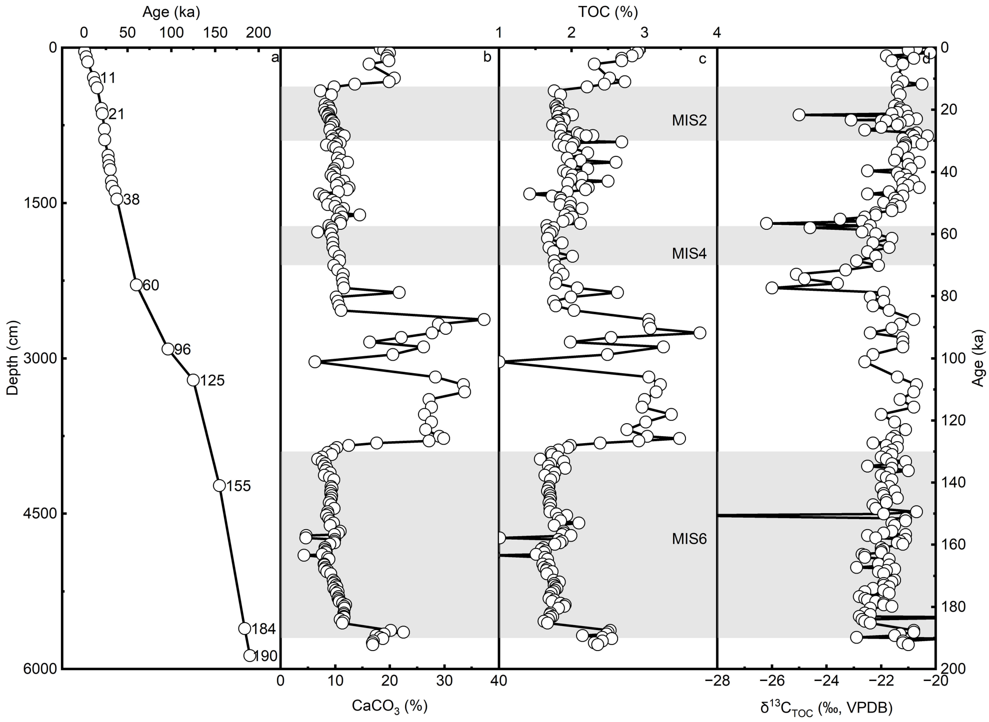

FIGURE 2
(A) Age model of core Z1. Downcore profiles for **(B)** the content of CaCO$_3$, **(C)** total organic carbon content, and **(D)** δ^{13}C value of TOC. **(A, B)** were analyzed in Dou et al. (2021).

4 Discussion

4.1 Productivity changes in the middle OT over the past 200 ka

TOC% and foraminiferal carbon isotopes are important proxies for paleo-productivity. An enhancement in sea surface primary productivity results in the consumption of more ^{12}C through photosynthesis, which leads to an enrichment in ^{13}C in surface seawater. At the same time, as organic matter sinks, it degrades and releases ^{12}C, which leads to a depletion of ^{12}C in surface bottom water (Spezzaferri, 1995; Li et al., 2017). As a result, higher sea surface primary productivity corresponds to positive planktonic δ^{13}C and a higher Δδ^{13}C$_{P\text{-}B}$ ratio (Jian et al., 2001; Tian et al., 2017). In core Z1, the trends for δ^{13}C$_{G.\ ruber}$ and Δδ^{13}C$_{P\text{-}B}$ ratio are very similar (Figures 3A, B). Positive values of δ^{13}C$_{G.\ ruber}$ and Δδ^{13}C$_{P\text{-}B}$ occurred during MIS 1-5, whereas negative δ^{13}C$_{G.\ ruber}$ and Δδ^{13}C$_{P\text{-}B}$ ratios occurred during MIS 6, indicating much lower surface productivity conditions during MIS 6 (Figure 2C). TOC% was lowest during MIS 6, indicating the lowest level of surface primary productivity, which is consistent with the Δδ^{13}C$_{P\text{-}B}$ data (Figure 3C). However, the TOC% also dropped during MIS 2-4, which is not recorded in the Δδ^{13}C$_{P\text{-}B}$ ratio.

The variation in surface primary productivity in the mid-OT observed in this study during the glacial-interglacial cycle corresponds well with some previous studies. Li et al. (2017) reconstructed export productivity over the past 91 ka using reactive P from sediment core MD012404 in the mid-OT and found that the productivity was modulated by the penetration depth of NPIW, which hinders the supply of deep high-nutrient water to surface seawater. Shao et al. (2016) proposed that a dry and cold climate resulted in low nutrient levels, while the rising sea level and warm climate during the deglacial period contributed to elevated primary productivity. These reports suggested that low productivity in the OT during glacial periods may be due to water mass intrusion, climate, KC and other factors.

Atmospheric dust input was also high, with dry and cold climates during glacial periods, and Fe and Si carried by aeolian dust further increased the nutrient levels (Li et al., 2017). Furthermore, although the OT received terrestrial sediment input during glacial periods, in the deep water, sufficient time was available for organic matter to be degraded and utilized by marine organisms and eventually be buried in the sediments. δ^{13}C-TOC is often used to distinguish sources of organic matter. The δ^{13}C value of terrestrial organic matter, including C3 plants (δ^{13}C ranging from -23 to -30‰) and freshwater aquatic plants and plankton (δ^{13}C ranging from -25 to -30‰), is more negative. The δ^{13}C of marine organic matter is more positive (usually taken as -19 ~ -22‰), which is composed of marine organisms (δ^{13}C ranging from -10‰ to -22‰) and algae (δ^{13}C ranging from -20‰ to -25‰) (Fontugne & Jouanneau, 1987; Meyers, 1997; Shao et al., 2016). The average δ^{13}C-TOC of core Z1 is -21.8 ‰, and the overall value is stable, indicating that since MIS6, the sedimentary organic matter has basically been of marine authigenic origins.

Based on diverse geochemical parameters (Figure 3), the surface primary productivity may have been significantly affected by sea level variation and terrigenous inputs in the glacial-interglacial cycle. In accordance with previous studies, the content of $CaCO_3$ in the mid-OT was lower during glacial periods and higher during the interglacial periods (Figure 2B) (Chang et al., 2009; Dou et al., 2015; Dou et al., 2021). Additionally, the $CaCO_3$ content was highly synchronized with sea level changes, indicating that the production and burial of $CaCO_3$ in the mid-OT was closely related to sea level fluctuations and greatly influenced by terrigenous input (Jian et al., 2000; Chang et al., 2009). The OT is adjacent to the continental shelf, and the sea level could have dropped by approximately 120 m during the glacial period (Saito et al., 1998). The lower sea level allowed a large amount of terrestrial matter supplied by the paleo-Yangtze River to be directly transported into the OT (Dou et al., 2010; Shao et al., 2016). The sedimentation rate in the OT during the glacial period was much higher than that in the interglacial period. As a result, TOC% and $CaCO_3$% in the glacial period decreased due to the dilution of the terrestrial sediment input during MIS 2-4 and MIS 6. Different from TOC% and $CaCO_3$%, the fluxes of TOC and $CaCO_3$ present higher values during the glacial period and lower values during the interglacial period (Figure 4) due to the higher sedimentation rate during the glacial period. Thus, there is no significant difference in surface primary productivity in MIS 1-5.

The obviously depleted $\Delta\delta^{13}C_{P\text{-}B}$ ratio during MIS 6 indicates low surface primary productivity at that time, and we speculate the difference in subsurface KC upwelling is the major reason for the prominent low surface productivity in OT during MIS 6. During MIS 2 and MIS 6, the sea level is similar (Figure 4G). But the subsurface KC upwelling is strong during MIS 2, and weak during MIS 6 (Vats et al., 2021). During MIS 6, Oligotrophic KC and weak subsurface upwelling led to poor-nutrient surface water. Consequently, the primary productivity is much lower during MIS 6, compared to MIS 2. In addition, enhanced marine hydrodynamics and the intrusion of the oligotrophic KC (Figure 5D) formed a barrier to sediment entry at the edge of the continental shelf (Zhao et al., 2021), further restricting the transport of shelf sediments to the OT, and the reduction in nutrient supply led to the decline in productivity (Lim et al., 2017; Zhao, 2017).

4.2 NPIW ventilation and oxygenation regulate OC burial

Based on the carbon isotopes of planktonic and benthic foraminifera, we found that the high TOC flux during the glacial periods corresponded to a low TOC content (Figures 4B, C). The TOC% in sediments was greatly affected by the dilution effect and the preservation of OC. Previous studies have reported that that preservation of OC is increased during glacial periods, which slightly contradicts our results (Figure 5A) (Martínez-García et al., 2014; Cartapanis et al., 2016; Li et al., 2018).

The variation in OC burial in the mid-OT was closely related to the redox conditions and the ventilation of the bottom water (Li et al., 2018). Based on modern oceanographic observations (Figures 1B, C), strong stratification could be found in the OT, and the KC had little effect on the deep water, which was mainly composed of low-salinity NPIW. Lateral deep water ventilation is closely related to the redox state of deep water (Cartapanis et al., 2011), and the redox environment has a large impact on OC burial. Therefore, deep water ventilation and the mineralization process under the oxidative environment over the past 200 ka may be the main factors controlling OC sequestration in the OT (Zou et al., 2020).

The intermediate water of the OT is mainly composed of the NPIW and the South China Sea Intermediate Water (SCSIW), which enters the OT through the channel east of Taiwan and the Kerama Gap (Figure 1) (Talley, 1993; Nakamura et al., 2013). NPIW forms at high latitudes in the North Pacific, is widely distributed at water depths of 300-800 m and is characterized by low salinity (~34.0-34.3 ‰) and oxidation (50-150 μmol/L) (Talley, 1993; Knudson & Ravelo, 2015; Zhao et al., 2021). Core Z1 was obtained from the mid OT, where it has been demonstrated to be significantly affected by the NPIW (Dou et al., 2015; Zou et al., 2020; Zhao et al., 2021). Therefore, the intrusion of glacial-enhanced NPIW in the OT may directly regulate the redox state of the bottom water (Okazaki et al., 2010; Knudson & Ravelo, 2015; Ujiié et al., 2016; Gong et al., 2019; Worne et al., 2019; Zhao et al., 2021).

With enhanced glacial NPIW ventilation, the oxygen in the water column was replenished, and the intermediate water remained in an oxidized state. The oxic environment was conducive to microbial mineralization. Particulate organic carbon (POC) settling from the upper layers could be fully degraded and utilized through mineralization, resulting in the lower TOC content during the last glacial period and MIS 6. A recent reconstruction of NPIW evolution and redox conditions using authigenic uranium (aU) over the past 400 ka (Figures 5B,C) indicated that the oxic deep water was correlated with intensified NPIW flow (Zhao et al., 2021). Other reconstruction work based on geochemical indices, such as the Mo/Mn ratio and numerical simulation, also illustrated the close relation between glacial NPIW ventilation and oxygen concentration in deep water (Okazaki et al., 2010; Gong et al., 2019; Zou et al., 2020).

With the warming climate and rising sea level, the TOC content showed a large increase in MIS5. Sea ice melt and increased precipitation weakened the formation of the NPIW (Worne et al., 2019), reducing the ventilation of deep water (Zhao et al., 2021). In addition, the stratification of the water column caused by the strengthened KC led to a decline in the oxygen concentration in the deep layer, promoting the burial of TOC under weakened mineralization conditions (Figure 5) (Dou et al., 2015; Zhao et al., 2021). The solubility of oxygen in seawater during the interglacial period likely decreased due to the rise in temperature. Temperature-influenced solubility changes could lead to the generation of hypoxia on geological timescales (Praetorius et al., 2015), so mineralization and OC burial may also be affected by seawater temperature to some extent. Zou et al. (2020) found that the increased Mo/Mn ratio and U_{excess} during the warm Bölling-Alleröd period both indicated the expansion of hypoxic intermediate water in the subtropical northwest Pacific.

The TOC content showed a stable trend during the last glacial period (MIS2-4), with a slight increase in MIS3 (Figure 5), which was also speculated to be mainly due to NPIW ventilation. The formation of the NPIW was reduced due to the warm climate in the

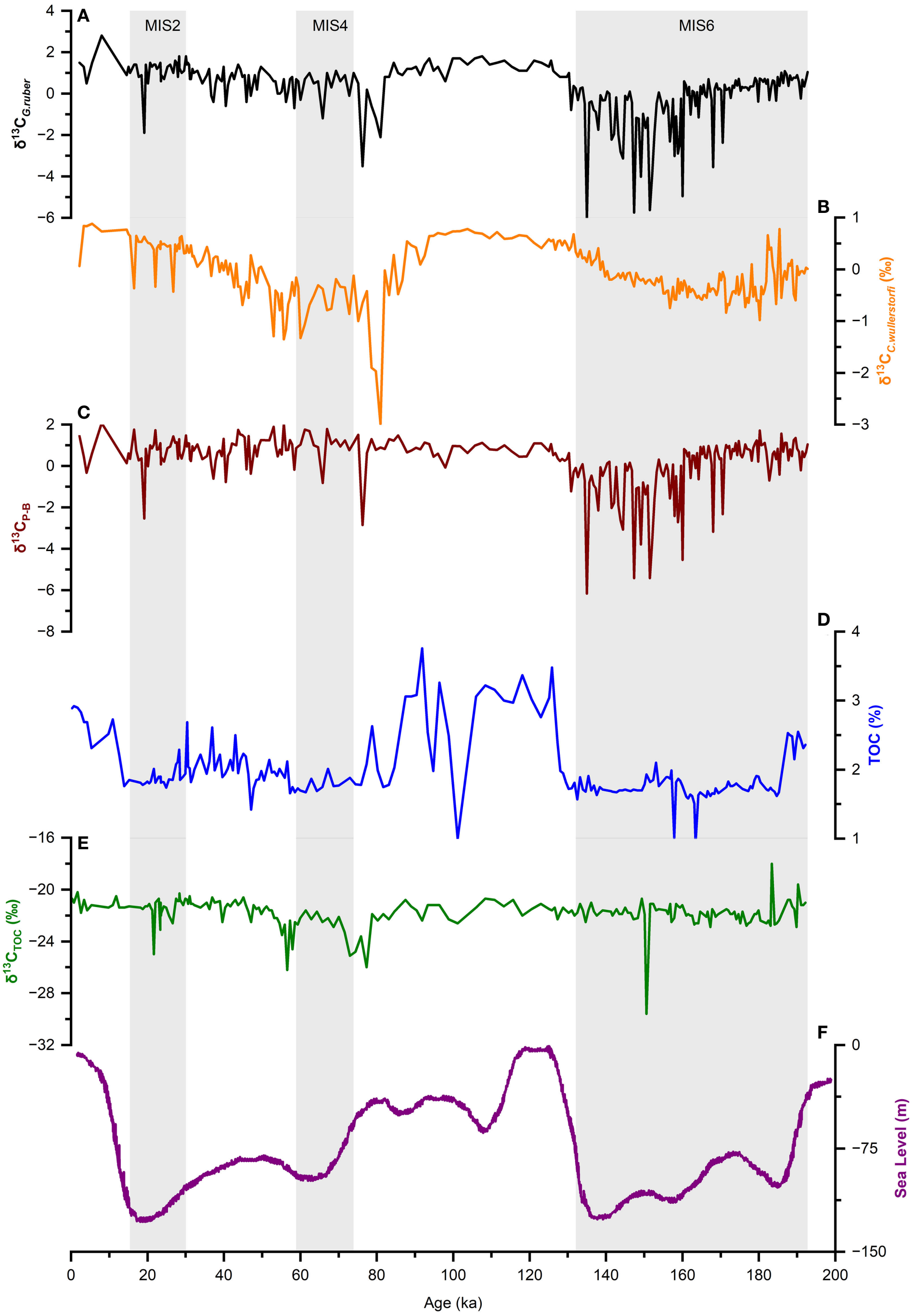

FIGURE 3

Main geochemical parameters of core Z1. **(A)** The $\delta^{13}C$ of planktonic foraminifera (*G*) *ruber*. **(B)** The $\delta^{13}C$ of benthic foraminifera (*C*) *wullerstorfi* (Dou et al., 2021). **(C)** The carbon isotope difference between benthic and planktonic foraminifera $\Delta\delta^{13}C_{P\text{-}B}$. **(D)** Total organic carbon content. **(E)** $\delta^{13}C$ value of TOC. **(F)** Sea level fluctuation (Lambeck & Chappell, 2001).

Holocene, while the KC increasingly influenced the OT (Figure 5) (Shi et al., 2014; Zou et al., 2020). Otherwise, terrestrial organic matter, which is indicated by lower $\delta^{13}C$-TOC values (Figure 3E), would become refractory after long-term transport and degradation, weakening mineralization. In addition, the enhanced stratification in the water column and the reduction in exchange between surface and deep water led to hypoxia in the bottom water, which promoted OC burial (Dou et al., 2015).

4.3 The mechanism of OC burial in the OT at the glacial-interglacial scale

The TOC% in the OT is affected by the sedimentation rate and the preservation of OC. During the glacial periods, the significantly higher sedimentation rate resulted in a low TOC% but corresponded to higher TOC flux because of the lower sea level and the greater amounts of sediment originating from the Yangtze River (Figure 6).

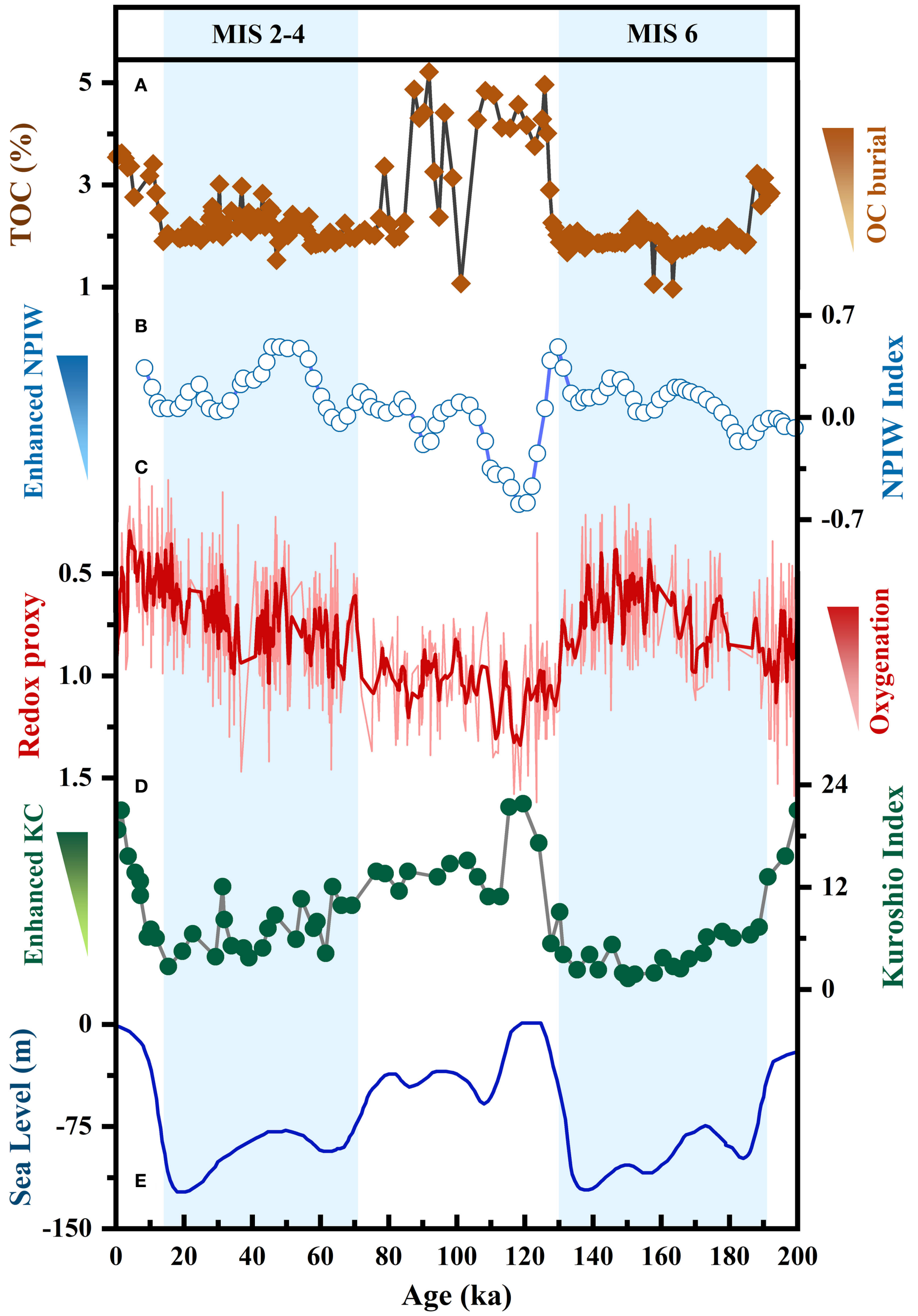

FIGURE 4
Comparison of TOC and CaCO3 accumulation rates in OT. **(A)** The sedimentation rate of core Z1. **(B)** The TOC flux. **(C)** TOC%. **(D)** CaCO3 flux. **(E)** CaCO3%. **(F)** The intensity of the Kuroshio intrusion (Matsuzaki et al., 2019). **(G)** Sea level fluctuation (Lambeck & Chappell, 2001).

In terms of OC preservation, we suggested that the limited contribution of the Kuroshio Current to vertical water exchange may only have a large impact on the upper 300-500 m of water under the strengthened Kuroshio Current. The deeper trough is mainly affected by NPIW, SCSIW or North Pacific Deep Water (NPDW) (Dou et al., 2015; Zhao et al., 2021). In a recent reconstruction of OC burial in the Northwest Pacific (water depth: 2670 m), it was shown that vertical water exchange was hindered due to the barrier formed by the enhanced glacial NPIW, so a hypoxic reducing environment was formed in the bottom water, which promoted the burial of OC (Zhang et al., 2022). We assumed that the water depth and topography of the site were crucial considering that core Z1 was collected from the west slope of the OT and the water depth was only 940 m. This location has been greatly affected by terrigenous materials and NPIW, so ventilation and related mineralization play important roles in regulating organic OC burial.

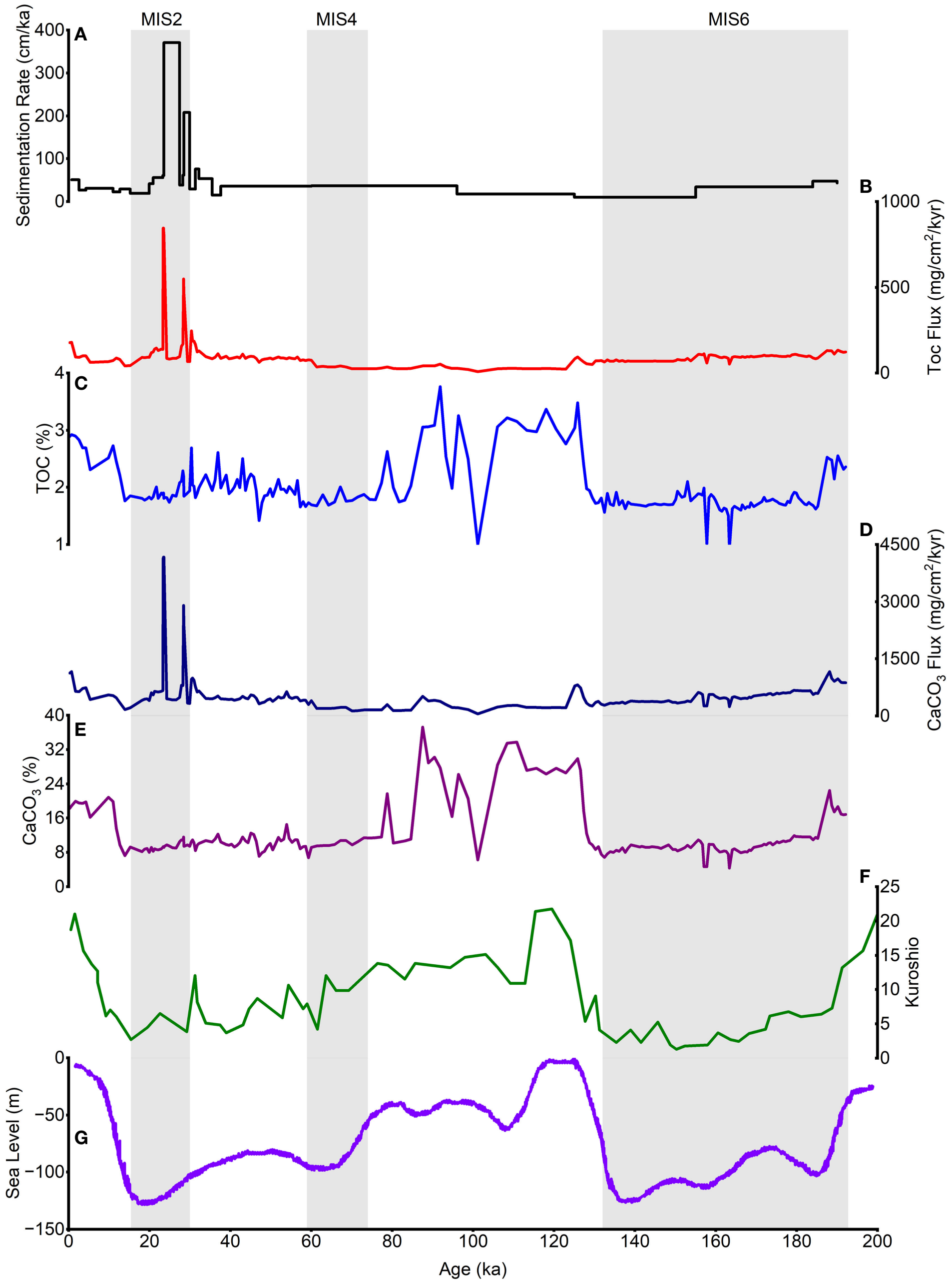

FIGURE 5
Comparison of TOC burial with major currents in the OT. **(A)** The OC burial conditions of Z1. **(B)** The intensity of NPIW ventilation (Worne et al., 2019). **(C)** Redox conditions of bottom water in the OT (Zhao et al., 2021). **(D)** The intensity of the Kuroshio intrusion (Matsuzaki et al., 2019). **(E)** Sea level fluctuation (Lambeck & Chappell, 2001).

The burial of OC was not correspondingly elevated due to enhanced mineralization because massive amounts of OC were decomposed into dissolved organic carbon (DOC) through microbial degradation and entered the large DOC pool in the ocean (Jiao et al., 2010). Previous studies have also shown that the enhancement in Pacific meridional overturning (PMOC) during the LGM promoted the ventilation of intermediate water in the North Pacific and reduced the nutrient content in the NPIW (Rae et al., 2020; Zhao et al., 2021).

5 Conclusions

Based on geochemical evidence, we reconstructed the evolution of OC burial and revealed the burial regime in the mid-OT over the past 200 ka. The lowest sea surface productivity mainly occurred in MIS 6, which may be attributed to changes in the paths of the oligotrophic KC. The sea surface productivity was higher and remained stable in MIS 1-5. The flux of TOC was higher in the glacial periods because of the lower sea level and consequently

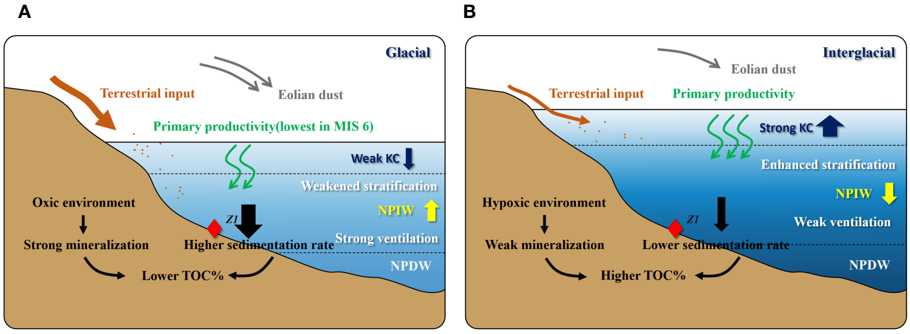

FIGURE 6
Schematic diagram of OC burial associated with NPIW ventilation and mineralization in mid-OT during glacial **(A)** and interglacial **(B)** periods (modified from (Zhang et al., 2022)).

enhanced terrestrial input. The reduced TOC% observed during glacial periods may be due to the dilution effect and poor OC preservation. Glacial-enhanced NPIW ventilation led to bottom water oxidation and promoted mineralization, which regulated the preservation of OC. The water depth and topography of the study site also mattered for the reconstruction of the evolution of OC burial. The stratification caused by the strengthened KC during interglacial periods could have resulted in reducing conditions in bottom water, facilitating better preservation of OC. This study demonstrates that the environmental conditions of diverse time scales and regions affect the burial of organic carbon.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material. Further inquiries can be directed to the corresponding authors.

Author contributions

YJ: Data curation, Visualization, Writing – review & editing, Writing – original draft. BZ: Writing – original draft, Data curation, Visualization, Writing – review & editing. TZ: Writing – review & editing, Writing – original draft. JZ: Writing – review & editing. XZ: Writing – review & editing. YD: Writing – review & editing. QL: Writing – review & editing. FC: Writing – review & editing. BH: Writing – review & editing. LD: Writing – review & editing, Writing – original draft.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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