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Data report: radiocarbon age of planktonic foraminifera collected at Site U1474, Natal Valley, IODP Expedition 361[1]

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Abstract

An age model for a marine sediment core is a prerequisite for paleoenvironmental studies. Here, we report 27 radiocarbon dates of planktonic foraminifera (24 dates for *Orbulina universa* and 3 for *Trilobatus sacculifer*) collected from International Ocean Discovery Program Expedition 361 (Southern African Climates) Site U1474 in the Natal Valley. The top to the bottom of Section 361-U1474F-1H-1 was used for the analysis. The results indicate that sedimentation is almost constant, extending to 42.0 ky BP at 140 cm below the seafloor. The obtained age-depth model is consistent with that of a marine sediment core obtained from a proximate site in a previous study and was confirmed by comparing the color reflectance of the sediment cores.

1. Introduction

An establishment of a robust age model for a marine sediment core is crucial to study environmental changes of the past. For the time period from common era (CE) 1950 to ~50,000 y ago, radiocarbon dating can provide reliable chronologies. Planktonic foraminifera shells (which consist of calcium carbonate) preserved in marine sediment cores are a reliable recorder of inorganic carbon dissolved in surface seawater, and thus are widely used to obtain ages model of the cores after ^{14}C marine reservoir correction, which is required because of the relatively slow carbon cycle in the ocean.

2. Methods and materials

The marine sediment core was collected from the Natal Valley in the southwest Indian Ocean using the advanced piston corer (APC) system on *JOIDES Resolution* during International Ocean Discovery Program (IODP) Expedition 361 in 2016 (31°13.00′S, 31°32.71′E; 3045 m water depth). Section 361-U1474F-1H-1 was used. This section is 150 cm long and consists of the following two lithologic units: (1) the upper 55 cm, which is foraminifera-bearing light yellowish clay, and (2) the lower 95 cm, which is foraminifera-bearing greenish gray clay. The intensity of bioturbation was slight to moderate, and there was no sign of turbidites in the section.

The marine sediment core was stored in a refrigerator until the Expedition 361 sampling party at Texas A&M University (USA) in October 2016. During the sampling party, subsamples from Hole U1474F were obtained using 2 cm wide 30 cm^3 scoop samplers; these were then shipped to a laboratory at Nagoya University (Japan). The subsamples were gently washed under running water

over a 63 µm sieve and dried at 60°C in an oven. The sieved materials were further divided into size fractions of 63–255, 255–300, 300–355, 355–425, 425–500, and 500–850 µm and stored in plastic vials. From the 500–850 µm size fraction, about 10 mg of shells of two species of planktonic foraminifera, *Orbulina universa* and *Trilobatus sacculifer*, were hand picked with a fine brush under a microscope and stored in 1.5 mL plastic tubes until radiocarbon analysis.

Subsequent radiocarbon analysis was conducted at a laboratory at the Atmosphere and Ocean Research Institute (AORI) (Japan). The shells were gently crushed between glass slides to open all their chambers and then transferred into vacuum vials. The samples were ultrasonicated with Milli-Q water, and the supernatant containing the suspended materials was removed. This was repeated several times until the supernatant became transparent. After removing the air in the vial under vacuum, the shells were reacted with phosphoric acid and the carbon dioxide produced was collected. The carbon dioxide was converted to graphite using an Fe catalyst at 620°C for 6–12 h. The target graphite samples were measured with a single-stage accelerator mass spectrometer (NEC, USA) installed at AORI.

Conventional ^{14}C ages were converted to calendar years before present (cal. y BP) using a Marine20 calibration curve (Heaton et al., 2020) with a local marine ^{14}C reservoir age of –1 ± 59 y (Southon et al., 2002; Maboya et al., 2018).

3. Results

A summary of the radiocarbon dating results is given in Table **T1**. In total, 24 radiocarbon dates for *O. universa* and 3 dates for *T. sacculifer* were obtained, and the results were consistent (radiocarbon date of *T. sacculifer* from a core depth of 120–122 cm had a slightly younger age by 2000 y compared with that of *O. universa* from the same subsample) (Figure **F1**). The calendar age of the top of Section 361-U1474F-1H-1 was 1786 ± 106 (1σ) cal. y BP. The sedimentation rate was almost constant throughout the section, and the calculated linear sedimentation rate was 3.5 cm/ky (Figure **F1**).

We compared the result with the age-depth model of marine sediment Core CD154-10-06P, which was obtained from the same site in the Natal Valley (31°10.36′S, 032°08.91′E; 3076 m water depth) (Simon et al., 2015). This sediment core is 969 cm long, contains foraminifera-bearing clay, and ^{14}C dates of planktonic foraminifera *Globigerinoides ruber* from the top 100 cm of the core have previously been reported (Simon et al., 2015). Using the same Marine20 calibration curve and local marine ^{14}C reservoir age, we recalibrated the 10 radiocarbon dates of Core CD154-10-06P that were measured at the Natural Environment Research Council Radiocarbon Laboratory (United Kingdom). The age-depth model of Core CD154-10-06P is consistent with that of Hole U1474F; there is nearly constant sedimentation with a core top (0–1 cm depth) age of 1808 ± 106 cal. y BP (1σ) and a linear sedimentation rate of 4.0 cm/ky (Figure **F1**).

The total reflectance (L*) of the two sediment cores also agreed with each other (Figure **F2**; Table **T2**). We calculated 1000 y interval averages for each sediment core, and a statistically significant correlation was observed between the L* records of the cores (r = 0.56; p = 0.0001; n = 42) (Figure **F2**). This result supports the robustness of age models of sediment cores based on radiocarbon dating. However, more fine tuning of age-depth models is likely possible using variations in L*. For example, the negative peaks seen at 12,001 cal. y BP for Hole U1474F and at 11,036 cal. y BP for Core CD154-10-06P are such candidates.

Table T1. Radiocarbon dates of planktonic foraminifera shells collected from marine sediment cores recovered from the Natal Valley. **Download table in CSV format.**

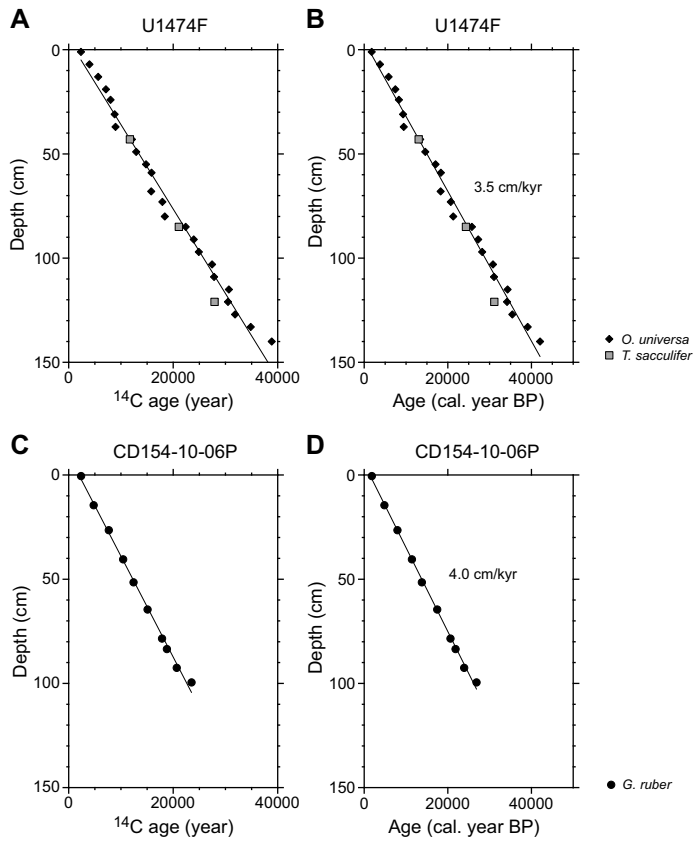

Figure F1. A, B. Age-depth model of Section 361-U1474F-1H-1. C, D. Age-depth model of Core CD154-10-06P, obtained from a proximate site to Site U1474. Solid lines = linear regressions for all data points.

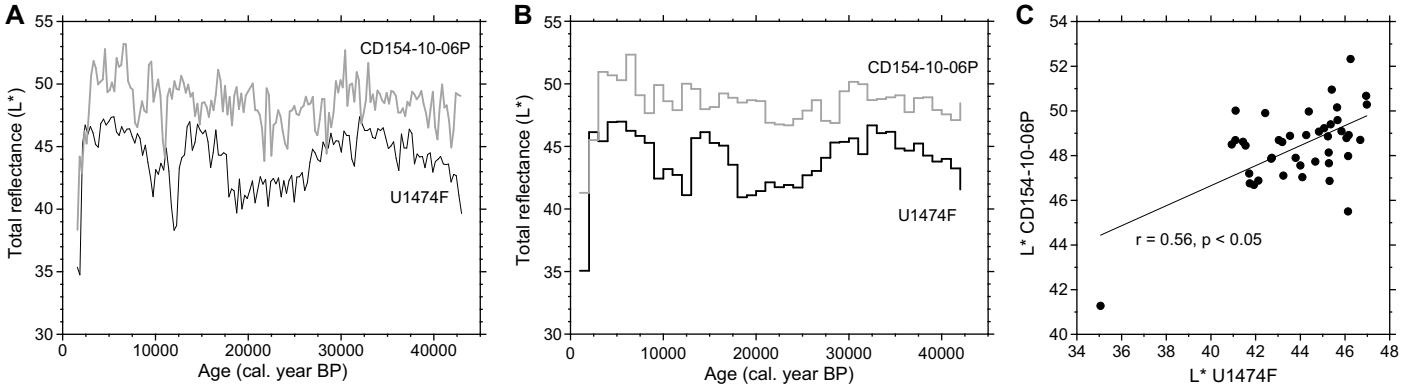

Figure F2. A. Total reflectance (L*) records, Site U1474 and Core CD154-10-06P. B. Same as A but with 1000 y interval averages of the L* records. C. Crossplot of the 1000 y interval averages of the L* records. Black line = linear regression.

Table T2. Time series of total reflectance (L*) of marine sediment cores recovered from the Natal Valley. **Download table in CSV format.**

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References

Heaton, T.J., Köhler, P., Butzin, M., Bard, E., Reimer, R.W., Austin, W.E.N., Bronk Ramsey, C., Grootes, P.M., Hughen, K.A., Kromer, B., Reimer, P.J., Adkins, J., Burke, A., Cook, M.S., Olsen, J., and Skinner, L.C., 2020. Marine20—the marine radiocarbon age calibration curve (0–55,000 cal BP). Radiocarbon, 62(4):779–820. **https://doi.org/10.1017/RDC.2020.68**

Maboya, M.L., Meadows, M.E., Reimer, P.J., Backeberg, B.C., and Haberzettl, T., 2018. Late Holocene marine radiocarbon reservoir correction for the southern and eastern coasts of South Africa. Radiocarbon, 60(2):571–582. **https://doi.org/10.1017/RDC.2017.139**

Simon, M.H., Ziegler, M., Bosmans, J., Barker, S., Reason, C.J.C., and Hall, I.R., 2015. Eastern South African hydroclimate over the past 270,000 years. Scientific Reports, 5(1):18153. **https://doi.org/10.1038/srep18153**

Southon, J., Kashgarian, M., Fontugne, M., Metivier, B., and W-S Yim, W., 2002. Marine reservoir corrections for the Indian Ocean and Southeast Asia. Radiocarbon, 44(1):167–180. **https://doi.org/10.1017/S0033822200064778**