Supplement of Clim. Past, 21, 2501–2523, 2025
https://doi.org/10.5194/cp-21-2501-2025-supplement

Climate of the Past
Open Access

Supplement of

Insights into the Middle–Late Miocene palaeoceanographic development of Cyprus (eastern Mediterranean) from a new δ^{18}O and δ^{13}C stable isotope composite record

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S1 Strontium isotope dating

Foraminiferal specimens were picked from the 355–400 µm size fraction, then crushed between two glass slides and transferred to clean vials. To ensure that all the clay had been removed from the foraminiferal tests, samples underwent further ultrasonic cleaning following crushing. This step of ultrasonic cleaning was repeated seven times for each sample. Each sample was ultrasonicated for fifteen seconds per round at this stage.

Carbonate samples (~25 µg) were weighed into PFA vials and leached in ammonium acetate to displace contaminant strontium on exchangeable sites and remove groundwater salts (Bailey et al., 2000). The remaining material was rinsed in deionised water two times before dissolution in dilute HCl (prepared by sub-boiling distillation in PFA (Mattinson, 1972). Strontium-specific resin was used to separate strontium from matrix elements (Horwitz et al., 1991; Horwitz et al., 1992), following a nitric acid extraction chemical procedure (adapted from Pin et al., 1994), in which samples were loaded in 8 molar (M) HNO_3, cleaned in sequential steps of 8M HNO_3 and 3M HNO_3, and strontium eluted in 0.01 M HNO3. The samples were loaded onto purified Re filaments in a Ta-emitter solution following ion exchange chemistry (Birck, 1986). Total procedural blanks yielded values of better than 350 pg, which are negligible relative to the amount of sample run (> 1µg).

Analyses were made on a VG-Sector-54 thermal ionization mass spectrometer using a three-cycle dynamic multicollector routine and an exponential mass fractionation correction relative to $^{86}Sr/^{88}Sr = 0.1194$ (Nier, 1938; Steiger and Jäger, 1977; Moore et al., 1982; Hans et al., 2013). Filaments were slowly heated to 2.4 A, focussing and filament current was adjusted to achieve a stable 1E-11 A ion beam on ^{88}Sr. Analyses are typically run for 15 blocks of 10 cycles (150 ratios), for approximately 1.5 hours. Rubidium interferences were monitored but were negligible. Repeated measurements of reference material NBS987 at similar run conditions during the period over which these analyses were made yielded a value of 0.710266 (+/-0.000007 2SD, n=10), within an uncertainty of the convention value of 0.71026 for the reference material, and indicates that the measurement repeatability is close to with the within-run uncertainty.

Strontium isotopic ages were calculated using the LOWESS Sr isotope Look-Up Table (Version 4: 08/04) (McArthur et al., 2001; McArthur and Howarth, 2004).

The total combined errors were then calculated from a combination of the uncertainties of the Sr isotopic analyses, and the error (upper and lower age range) of the LOWESS Sr isotope Look-Up Table (Version 4: 08/04) (McArthur et al., 2001; McArthur and Howarth, 2004). This timescale is consistent with commonly used ‘up to date’ geological timescales (e.g. Cohen et al., 2013; Raffi et al., 2020). Total combined error age ranges were calculated by combining 2 standard deviations of the analytical error, with the empirical error of the LOWESS “look-up table” to find the largest error range (McCay et al., 2013). Maximum age was obtained by subtracting 2σ (standard deviation) from the mean isotopic value and finding the age for this value on the ‘upper age limit curve’ of the LOWESS Sr Curve. Minimum age was obtained by adding 2σ (standard deviation) to the mean isotopic value and finding the age for this value on the ‘lower age limit curve’ of the LOWESS Sr Curve.

S2 Smoothing of data

In order to allow long-term trends in geochemical and temperature records to be identified, smoothed data are shown in figures (bold lines) together with measured values (thin lines with box markers). These data were smoothed using a nonparametric LOESS (locally estimated scatterplot smoothing) quadratic regression (Cleveland, 1979; Cleveland and Devlin, 1988) with a locally weighted function equivalent to 60 kyr.

S3 Age model

The production of the age model used in this study is discussed in sections 2.7 and 3.4 of the article. The additional figures provided in this supplement show the biohorizons used to refine the age model, and the splice point used to produce the composite record (Fig. S1) and the resultant sedimentation rates calculated from the final age model (Fig. S2 & Fig. S3).

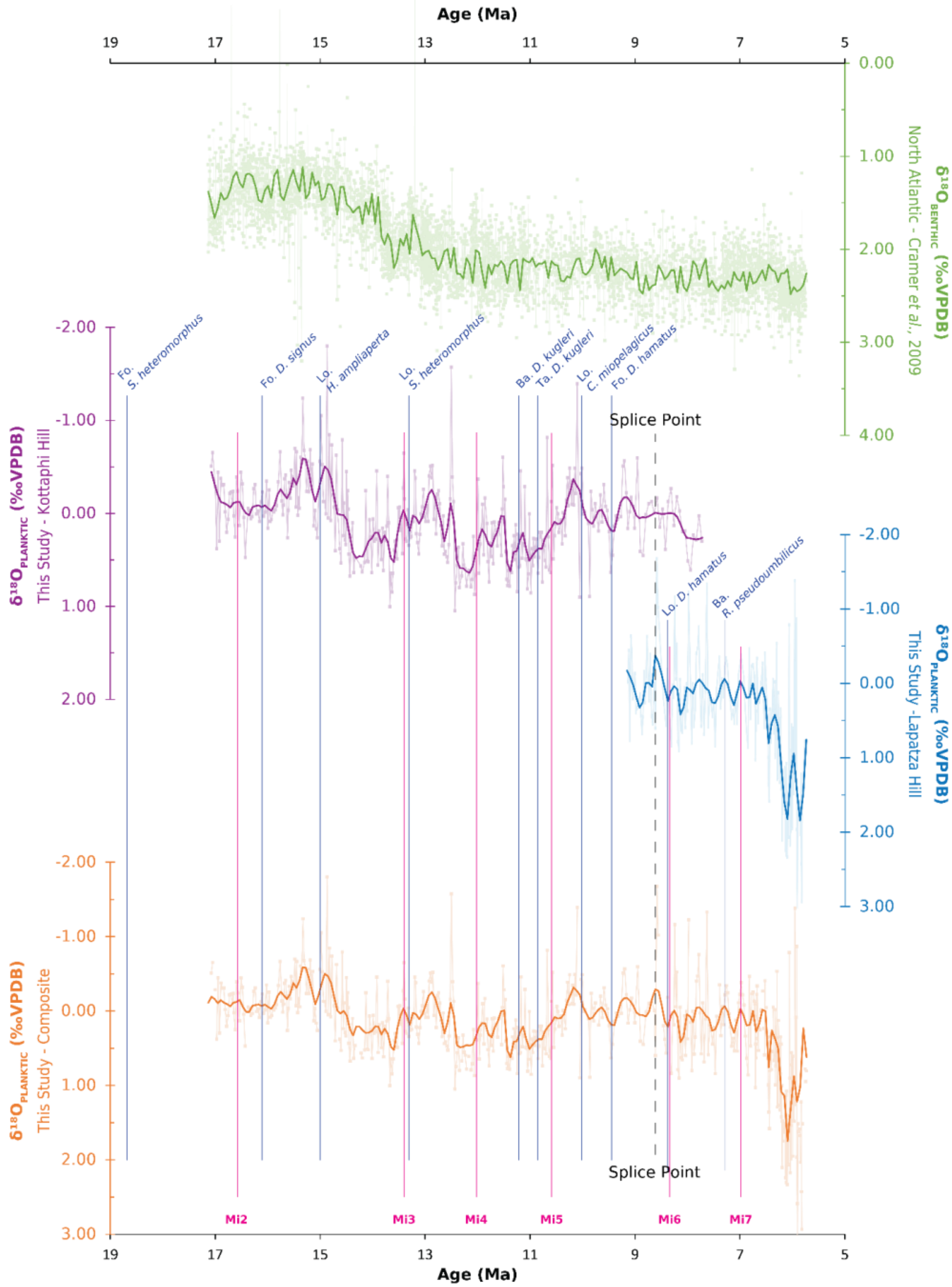

Figure S1 Graph showing the final adjusted age model. The Kottaphi Hill and Lapatza Hill $\delta^{18}O_{PLANKTIC}$ records are shown relative to the reference $\delta^{18}O_{BENTHIC}$ record of Cramer et al. (2009). Biohorizons used for calcareous nannofossil biostratigraphy are also shown, together with the Miocene oxygen isotope events of Miller et al. (1991, (2020). Fine lines plot the measured $\delta^{18}O$ values. Bold lines show the δ18O smoothed by a locally weighted function over 60 kyr.

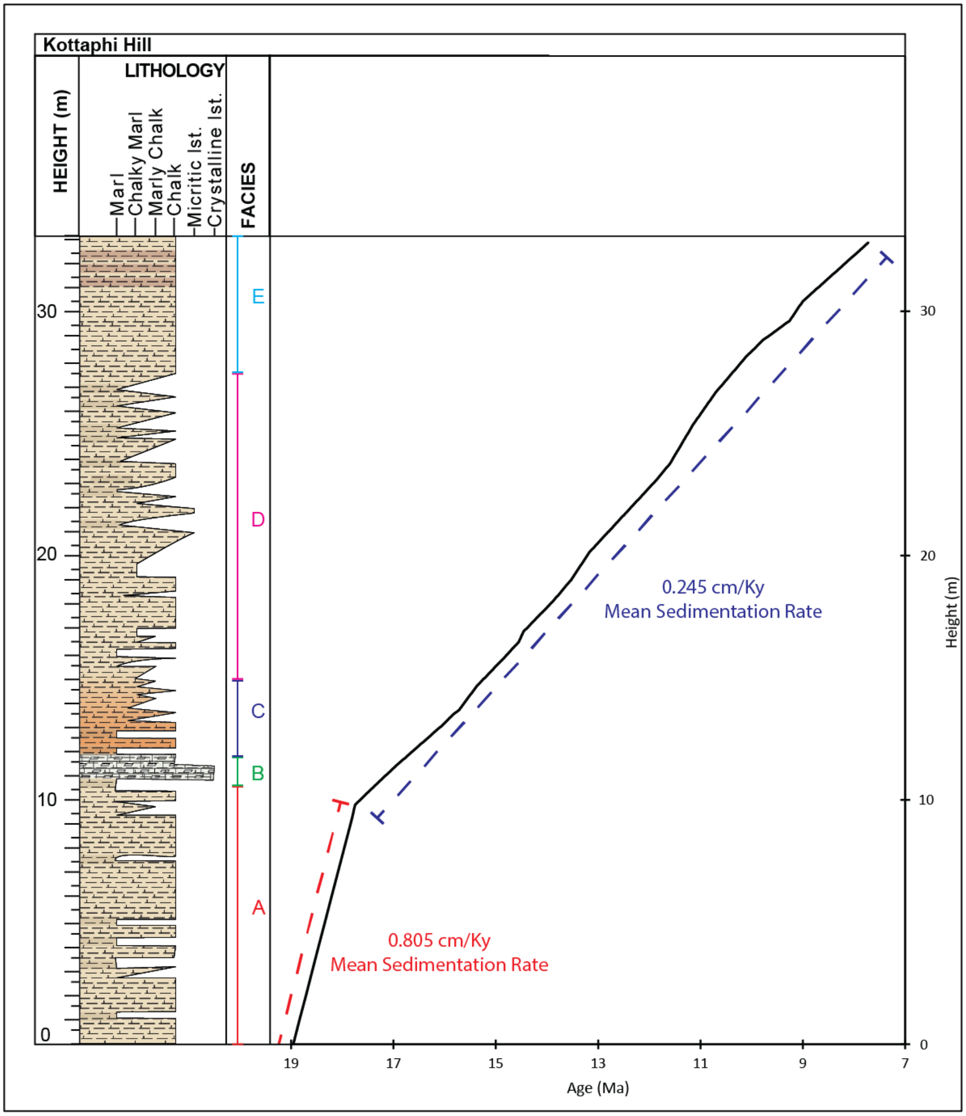

Figure S2 Plot of Age (Ma) versus Height (m) for the Kottaphi Hill succession shown relative to the simplified stratigraphic column of the succession. Average sedimentation rates are shown for two intervals of the succession.

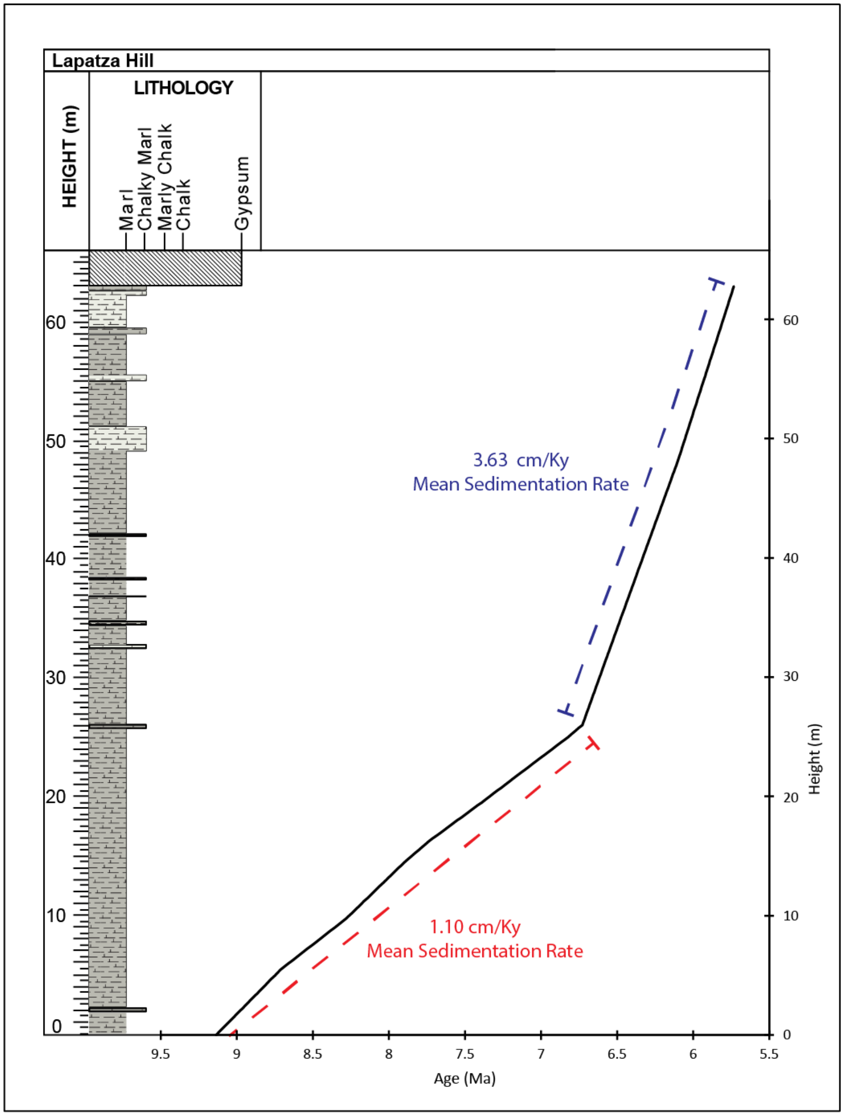

Figure S3 Plot of Age (Ma) versus Height (m) for the Lapatza Hill succession shown relative to the simplified stratigraphic column of the succession. Average sedimentation rates are shown for two intervals of the succession.

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