U-Th isochron dating of the marine oxygen-isotope record

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Dating marine records of climatic and oceanographic change has proved problematic. Current age models for events beyond the ^{14}C age range are constructed by tuning the marine oxygen-isotope record to northern-hemisphere insolation (e.g. Imbrie *et al.* 1984). These models rely on an assumed northern-hemisphere mechanism for climate change and have an absolute precision limited to about half the precession cycle (~10,000 years). Recent work (Slowey *et al.* 1996) has demonstrated that aragonite-rich sediments from the Bahamas are amenable to U-Th dating and may provide a high-precision chronology for the last 350 kyr which is independent of any assumed mechanism. Early work successfully dated interglacials, during which Bahamian sediments are dominated by aragonite. But dating of other periods is more problematic as sediment aragonite percentages are lower.

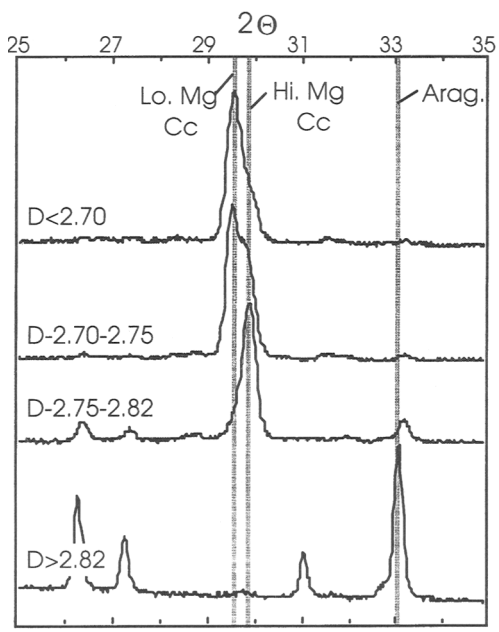

FIG. 1. XRD traces for four density separates from a deglacial Bahamas slope sediment. The density of sodium polytungstate used for each separate is shown, and the largest peak of the three types of carbonate contained in the bulk sediment indicated in grey.

Techniques

In this study, we have used sodium-polytungstate heavy liquids to separate three carbonate phases from Bahamas sediment. Separations are surprisingly good (see Fig. 1); do not feature high U and Th blanks; and provide carbonates with similar ^{14}C ages when performed on young samples. A straightforward isochron technique cannot be used with these separates, however, as there are three Th components - radiogenic, scavenged, and detrital (carbonate separates generally contain small amounts of detrital material). Instead, measured isotope ratios are first corrected for the detrital component using measured Al concentrations, and final isochrons therefore only include two Th components. This approach requires knowledge of element and isotope ratios in the detrital fraction. A suite of 21 wind-blown dust samples collected at Bermuda allow an assessment of these values (see Table 1).

Preliminary results

We have focused on dating the timing of the penultimate deglaciation as this is controversial

TABLE 1. Average element weight ratios and isotopic ratios for a suite of 21 Saharan dusts collected by air filtering at Bermuda and washed prior to analysis to remove sea-salt. Errors are 2 s.d.

	Average dust
Th/U	4.3 ±0.7
U/Al ($\times 10^{-5}$)	4.0 ±1.0
Th/Al ($\times 10^{-5}$)	17.1 ±1.5
($^{234}U/^{238}U$)	1.16 ±0.08
($^{230}Th/^{232}Th$)	0.85 ±0.53

(e.g. Winograd *et al.* 1997) and is important for our understanding of the mechanisms controlling the ice-age cycle (Broecker and Henderson, In Press). An example isochron is shown in Fig. 2 for the midpoint of the penultimate deglaciation. The spread of isotope ratios is sufficient to give a meaningful age but the correction for detrital U and Th, due to the uncertainty in the dust values, causes the error on this age to be large.

Continuing work

Efforts are now underway to improve the precision of this promising dating technique. The magnitude of the required detrital correction has been reduced by performing a more thorough pre-treatment of samples prior to heavy liquid separation. Isochrons with samples pre-treated in this way from across the two most recent deglaciations will be shown.

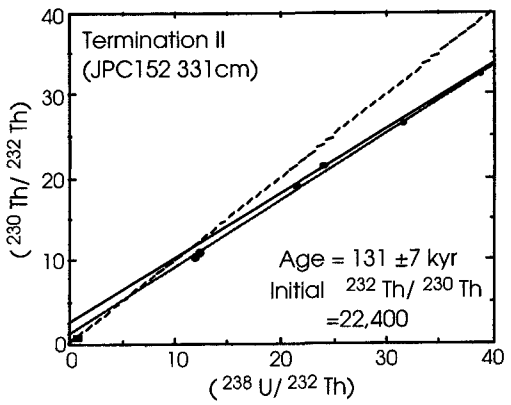

FIG. 2. Example U-Th isochron for the midpoint of the penultimate deglaciation. Density separates equivalent to the three lower curves on Fig. 1 were taken from 331 cm in core JPC152. Oxygen isotopes and bulk sediment U-Th ages for this core are given in Slowey *et al.* (1996). The dashed line is the isoline; the grey line the measured isochron; and the black line the final isochron corrected for detrital material with a composition at the black square. The corrected isochron gives an initial $^{232}Th/^{230}Th$ atom ratio of 22400, within the range observed for modern seawater.

References

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