In a paper by David A. Hodell, Daniel W. Müller, Paul F. Ciesielski, and Gregory A. Meade, entitled "Synthesis of oxygen and carbon isotopic results from Site 704: implications for major climatic-geochemical transitions during the late Neogene," Figures 1 through 6 were incorrectly represented by earlier, superseded versions. Reprinted below and following are pages 476–478 of SR Vol. 114, with the correct Figures 1 through 6 shown.

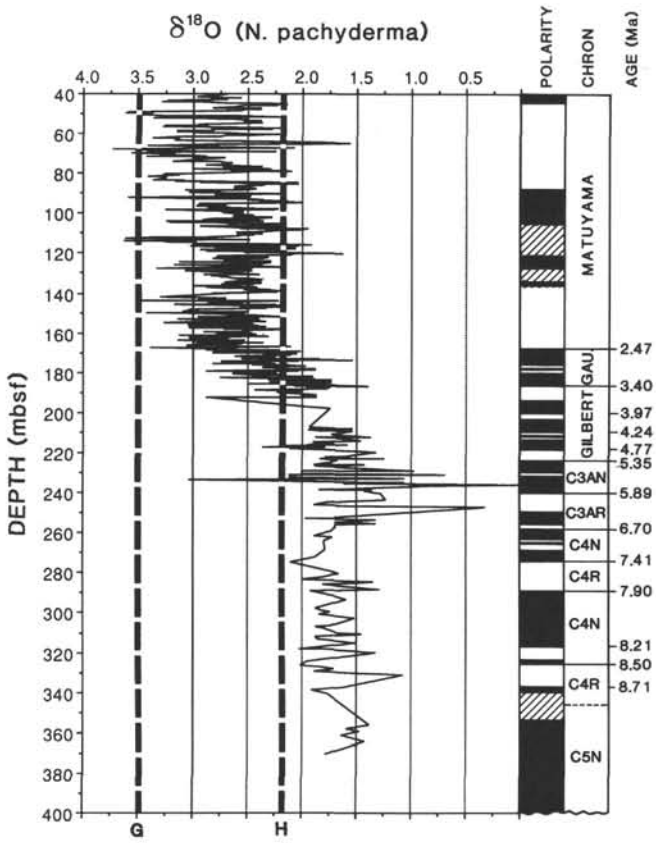

Figure 1. Oxygen isotopic results (per mil relative to PDB) of the planktonic foraminifer *Neogloboquadrina pachyderma* (sinistral) from Site 704. Late Miocene–early Pliocene data are from Müller et al. (this volume) and Pliocene-Pleistocene data are from Hodell and Ciesielski (this volume). The hatched pattern in the magnetostratigraphy (after Hailwood and Clement, this volume) reflects uncertainty in the placement of some polarity reversal boundaries. Note increases in average $\delta^{18}O$ values between 210 and 200 mbsf (4.2–3.9 Ma) and across the Gauss/Matuyama boundary (2.47 Ma) at 169 mbsf. For comparison, the glacial (G) $\delta^{18}O$ value of *N. pachyderma* at this latitude is ~3.5°/oo and the Holocene (H) value is ~2.2°/oo (Charles and Fairbanks, 1990).

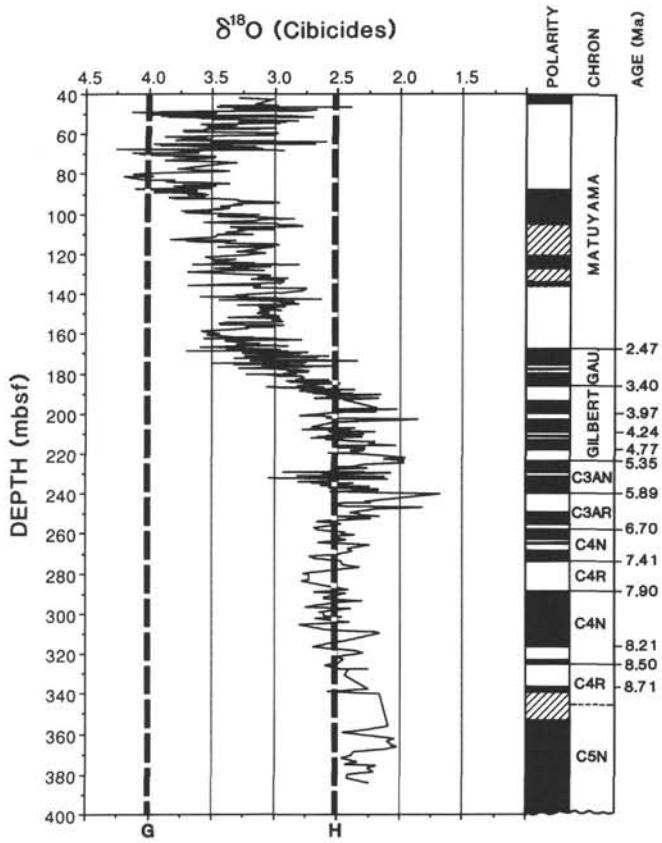

Figure 2. Oxygen isotopic results (per mil relative to PDB) of mixed species of benthic foraminifers belonging to the genera *Cibicides* and *Planulina* from Site 704. Sources of isotopic and magnetostratigraphic data are the same as for Figure 1. Note the progressive increase in benthic $\delta^{18}O$ values during the Gauss Chron. For comparison, the expected $\delta^{18}O$ values for *Cibicides* for the last glacial (G) and Holocene (H) periods are shown.

1.6°/oo–1.7°/oo), which are also consistent with the signal amplitude in the upper 40 m at Site 704.

At Site 704, benthic $\delta^{18}O$ values averaged 2.25°/oo between 9.7 and 8.7 Ma (380–340 mbsf) and increased to 2.5°/oo by 8.3 Ma (320 mbsf; Fig. 2). From 6.3 to 5.4 Ma (250–226 mbsf), the benthic oxygen isotopic record was marked by a relatively high-amplitude signal with maximum $\delta^{18}O$ values reaching 3°/oo. During the late Miocene, average benthic $\delta^{18}O$ values were less than the estimated Holocene core-top value (2.5°/oo–2.6°/oo), but Holocene values were commonly exceeded during Chrons 4 and C3AN.

The progressive increase of benthic $\delta^{18}O$ values during the Gauss (180–168.72 mbsf) culminated at the Gauss/Matuyama boundary (2.47 Ma). During the Gauss, benthic $\delta^{18}O$ values commonly exceeded Holocene values, but never reached values comparable to the last glacial maximum (4.1°/oo–4.2°/oo). The amplitude of the $\delta^{18}O$ signal progressively increased upsection during the Pleistocene, and $\delta^{18}O$ values first reached 4°/oo at 88 mbsf (1.5–1.6 Ma).

The oxygen isotopic data of fine-fraction carbonate bears little resemblance to either the planktonic or benthic $\delta^{18}O$ records (Fig. 3). A complete description of the record is given in Mead et al. (this volume). One interesting feature of the record is the high amplitude of the signal above 40 mbsf (<0.93 Ma), where the variation is as great as 4.5°/oo.

Carbon Isotopes

The carbon isotopic record of *N. pachyderma* is illustrated in Figure 4. Typical glacial and Holocene $\delta^{13}C$ values from a nearby piston core are provided for comparison. The average amplitude of the $\delta^{13}C$ signal for the last climatic cycle was 0.8°/oo in the Southern Ocean (Charles and Fairbanks, 1990).

Carbon isotopic values of *N. pachyderma* averaged ~1.5°/oo during much of the late Miocene, between 9.7 and

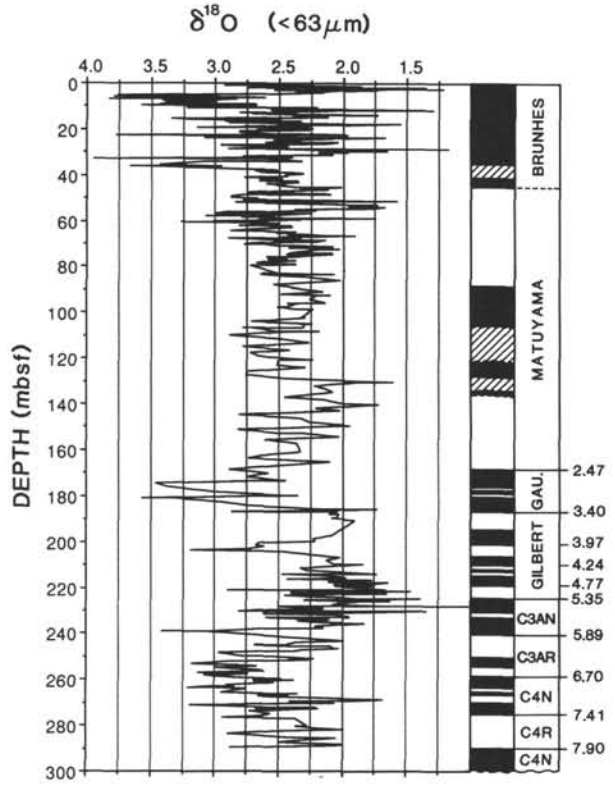

Figure 3. Oxygen isotopic results (per mil relative to PDB) of fine-fraction (<63 μm) carbonate from Site 704. Isotopic data are from Mead et al. (this volume) and the magnetostratigraphy is after Hailwood and Clement (this volume).

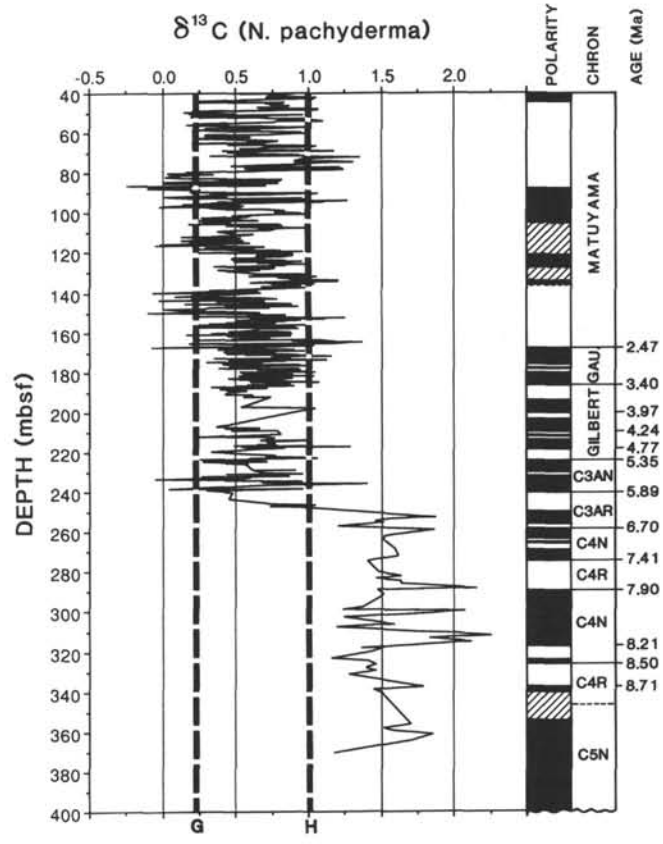

Figure 4. Carbon isotopic results (per mil relative to PDB) of the planktonic foraminifer *Neogloboquadrina pachyderma* (sinistral) from Site 704. Sources of isotopic and magnetostratigraphic data are the same as for Figure 1. The decrease in $\delta^{13}C$ values between 255 and 245 mbsf (6.4–6.0 Ma) corresponds to the late Miocene Chron C3AR (Epoch 6) carbon shift. For comparison, typical glacial (G) and Holocene (H) $\delta^{13}C$ values are designated for this latitude (Charles and Fairbanks, 1990).

~6.4 Ma (~380–255 mbsf; Fig. 4). These values are about 0.5‰ heavier than Holocene $\delta^{13}C$ values at this location. Between ~6.4 and 6.0 Ma (255–245 mbsf), $\delta^{13}C$ values decreased by 1‰ and averaged 0.4‰ during the remainder of Hole 704B. Although some trends are evident in the upper 250 m, the amplitude of the planktonic $\delta^{13}C$ signal was fairly constant and averaged 1‰ after 6.4 Ma (Fig. 4). This amplitude is roughly comparable to the variability observed between the Holocene and last glacial maximum.

Similar to the planktonic record, benthic $\delta^{13}C$ values also averaged ~1.5‰ between 9.7 and 6.4 Ma (380–255 mbsf; Fig. 5). These values are ~1.25‰ more positive than typical Holocene values at this site. From ~6.4 to 6.0 Ma (255–245 mbsf), benthic $\delta^{13}C$ values decreased by 1‰ and averaged ~0.5‰. The amplitude of $\delta^{13}C$ variation between 6.0 and 2.47 Ma was approximately 1‰ and varied about the estimated Holocene value.

Beginning at 2.5–2.4 Ma (168.72 mbsf), benthic $\delta^{13}C$ values decreased and averaged 0.0‰ during the early Matuyama. The amplitude of the benthic $\delta^{13}C$ signal progressively increased, reaching a maximum range of 1.5‰ during the late Matuyama. This amplitude is slightly greater than that observed for *Cibicides* in the Southern Ocean between the Holocene and last glacial maximum (Charles and Fairbanks, 1990).

Major trends in the $\delta^{13}C$ of fine-fraction carbonate are roughly similar to the benthic $\delta^{13}C$ record during the late Neogene, but lead and lag relationships exist (Fig. 6). Between 7.9 and 6.4 Ma (290–255 mbsf), carbon isotopic values were fairly constant and averaged 2‰. Beginning at 6.4 Ma (255 mbsf), fine-fraction $\delta^{13}C$ values began to decrease with the exception of two anomalously positive points near 240 mbsf. This trend of decreasing $\delta^{13}C$ values continued until 4.2 Ma (210 mbsf). This decrease is roughly coincident with the late Miocene carbon shift, as observed in the foraminiferal isotopic records, except that the shift in the fine fraction occurred over a period of 2 m.y. rather than a few hundred thousand years. Between ~2.7 and 2.5 Ma (170–169 mbsf), fine-fraction $\delta^{13}C$ values abruptly decreased by ~1.5‰. This fine-fraction $\delta^{13}C$ shift slightly precedes the decrease in benthic $\delta^{13}C$ that occurred at 2.5 Ma (Fig. 5). Above the

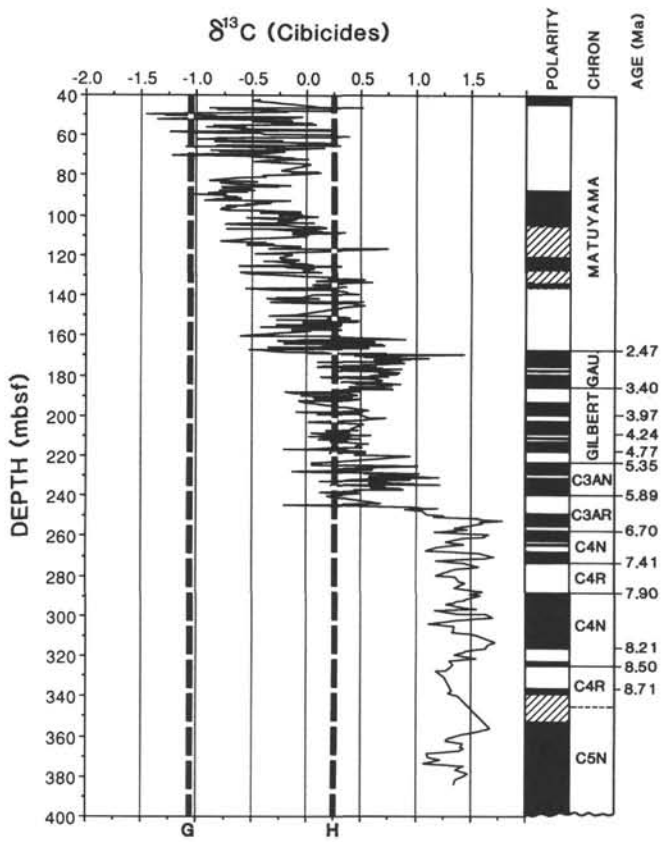

Figure 5. Carbon isotopic results (per mil relative to PDB) of mixed species of benthic foraminifers belonging to the genera *Cibicides* and *Planulina* from Site 704. Sources of isotopic and magnetostratigraphic data are the same as for Figure 1. Note the two-step decrease in benthic $\delta^{13}C$ values between 255 and 245 mbsf (6.4–6.0 Ma) and at the Gauss/Matuyama boundary (169 mbsf; 2.47 Ma). For comparison, $\delta^{13}C$ values are provided for the Holocene (H) and last glacial maximum (G) from a nearby core in the subantarctic South Atlantic (Charles and Fairbanks, 1990).

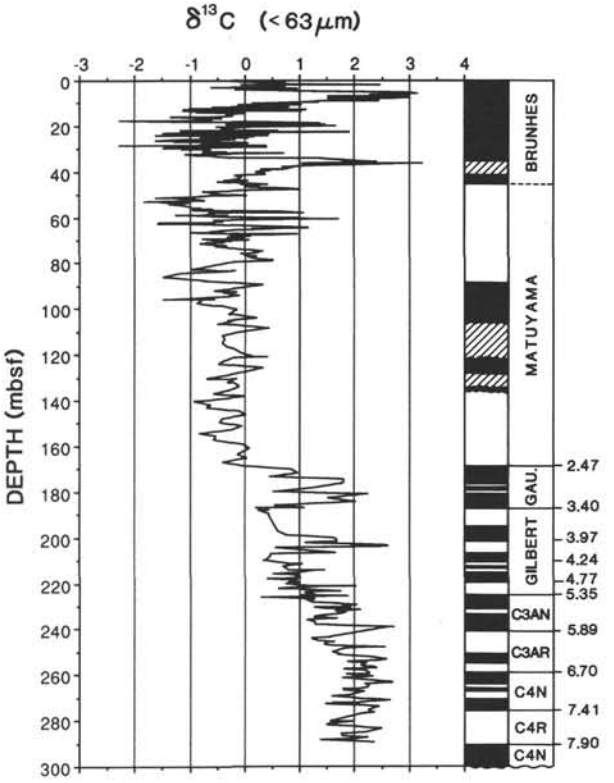

Figure 6. Carbon isotopic results (per mil relative to PDB) of fine-fraction (<63 μm) carbonate from Site 704. Sources of isotopic and magnetostratigraphic data are the same as for Figure 3. Note the two-step decrease in fine-fraction $\delta^{13}C$ values between 255 and 210 mbsf (6.4–4.2 Ma) and at the Gauss/Matuyama boundary (169 mbsf; 2.47 Ma). Also note the high-amplitude fluctuations in the upper 40 m at Site 704.

Gauss/Matuyama boundary, fine-fraction $\delta^{13}C$ values averaged −0.5‰ and the amplitude of the signal was relatively low until ~1.4 Ma (75 mbsf). Above this level, the amplitude of the $\delta^{13}C$ signal increased markedly and the variation was as great as ~5‰.

DISCUSSION

The late Neogene isotopic records of Site 704 in the subantarctic Southern Ocean are marked by a series of steps or transitions from one climatic-geochemical state to another. Two important transitions in subantarctic paleoceanographic conditions occurred during the late Miocene (~6.4–4.8 Ma) and late Pliocene (~2.5 Ma).

The late Miocene event began with the carbon shift at 6.4 Ma (255 mbsf). The $\delta^{13}C$ values of planktonic and benthic foraminifers show a synchronous decrease of 1‰ between 6.4 and 6.0 Ma (Figs. 4 and 5), whereas the fine-fraction $\delta^{13}C$ record decreases gradually between 6.4 and 4.2 Ma (Fig. 6). The carbon shift during Chron C3AR, observed in surface and deep waters at numerous sites in all ocean basins, signals a global decrease in the mean ^{13}C content of total dissolved CO_2 in the oceans. This global event must partly reflect a change in the proportion of carbon stored as organic carbon as opposed to carbonate carbon in sediments, such that organic carbon burial rates decreased relative to carbonate accumulation (Berger and Vincent, 1986).

A new observation from Site 704 is that the beginning of the carbon shift coincides with a time of decreasing benthic $\delta^{18}O$ values, suggesting warming or decreased global ice volume (Müller et al., this volume). This isotopic evidence is contrary to previous suggestions that the carbon shift was associated with a glacio-eustatic regression that increased erosion rates of organic-rich sediments from the continental shelves. If true, then the initial mechanism of decreased organic carbon burial must be related to tectonic uplift of the continents or changes in storage of organic carbon in deep-sea sediments (for a more complete discussion see Müller et al., this volume). This