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A Revisionist View of the Mid-Pleistocene Transition

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The Mid-Pleistocene Transition (MPT) is commonly characterized as a change in both temperature and ice volume from smaller amplitude, 41-kyr variability to higher amplitude, ~100-kyr variability in the absence of any significant change in orbital forcing. Here we reassess these characteristics based on our new reconstructions of changes in global mean surface temperature (DGMST) and global mean sea level over the last 2.5 Myr. Our reconstruction of DGMST includes an initial phase of long-term cooling through the early Pleistocene followed by a second phase of accelerated cooling during the MPT (1.5-0.9 Ma) that was accompanied by a transition from dominant 41-kyr low-amplitude periodicity to dominant ~100-kyr high-amplitude periodicity. Changes in rates of long-term cooling and variability are consistent with changes in the carbon cycle driven initially by geologic processes followed by additional changes during the MPT in the Southern Ocean carbon cycle. The spectrum of our sea-level reconstruction is dominated by 41-kyr variance until ~1.2 Ma with subsequent emergence of a ~100-kyr signal that, unlike global temperature, has nearly the same concentration of variance as the 41-kyr signal during this time. Moreover, our sea-level reconstruction is significantly different than all other reconstructions in showing fluctuations of large ice sheets throughout the Pleistocene as compared to a change from fluctuations in smaller to larger ice sheets during the MPT. We attribute their longer period variations after the MPT to modulation of obliquity forcing by the newly established low-frequency CO_2 variability. Specifically, prior to reaching their maximum size at the end of each ~100-kyr interval, ice-sheet response to periods of lower CO_2 was modulated by higher obliquity, and vice versa, with the times of maximum ice-sheet growth only occurring when low CO_2 combined with the next obliquity low. Ice sheets then began to melt in response to the next increase in obliquity, with the subsequent

sequence of events and feedbacks leading to a termination. High-resolution ice-core CO_2 records that extend beyond 0.8 Ma are needed to test this hypothesis. Otherwise, large ice sheets shared a common size threshold throughout the Pleistocene equivalent to sea level below -80 m that, when exceeded, resulted in a termination that was paced by the next increase in obliquity.