Middle Miocene lineages in the calcareous nannofossil genus *Discoaster*

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Research was conducted on the entire Miocene composite section from ODP Leg 154 (Ceara Rise, Western Equatorial Atlantic) between 2001 and 2008. The main purpose was to calibrate the latest cyclostratigraphic-based time scale to the nannofossil biostratigraphic framework in the deep-water Gulf of Mexico. Routine sampling was done at 20 kyr intervals, with some intervals sampled at 10 kyr resolution.

Middle Miocene lineages for discoasters with large central areas are presented, including four species described between 1954 and 1981: *Discoaster deflandrei*, *Discoaster musicus*, *Discoaster kugleri* and *Discoaster sanmiguelensis*. Eight new species within these lineages are proposed to account for variations in morphology with demonstrated stratigraphic utility. The main variations in morphology used to delineate these forms with large central areas are:

1) central area periphery (rounded or hexagonal);
2) distal central area (presence/absence of a knob);
3) proximal central area (presence/absence of knobs and ridges)
4) ray dimensions (length and width);
5) ray outline (tapered, parallel-sided, flared);
6) ray terminations (bifurcated, rounded, pointed, indented, notched).

These species normally range between 8-15 microns, but very rare specimens less than 8 microns also occur. Comparisons, including schematic drawings and light micrographs, are presented to differentiate four different lineages and their associated species. Their stratigraphy is then presented relative to defined middle Miocene zones. The total range of *Discoaster sanmiguelensis* and its variants is lowermost NN4 (17.69 Ma) to uppermost NN8 (11.04 Ma). The *Discoaster musicus* group ranges from the upper NN5 to the upper NN6 (13.08 Ma). *Discoaster kugleri* variants clearly predate (12.97 Ma) the base of Zone NN7 (11.910 Ma), as defined in both the NN and CN zonal schemes, by the first occurrence of *Discoaster kugleri*.