

Orbitally-tuned time scales and mapping the first appearances and extinctions of species in time and space

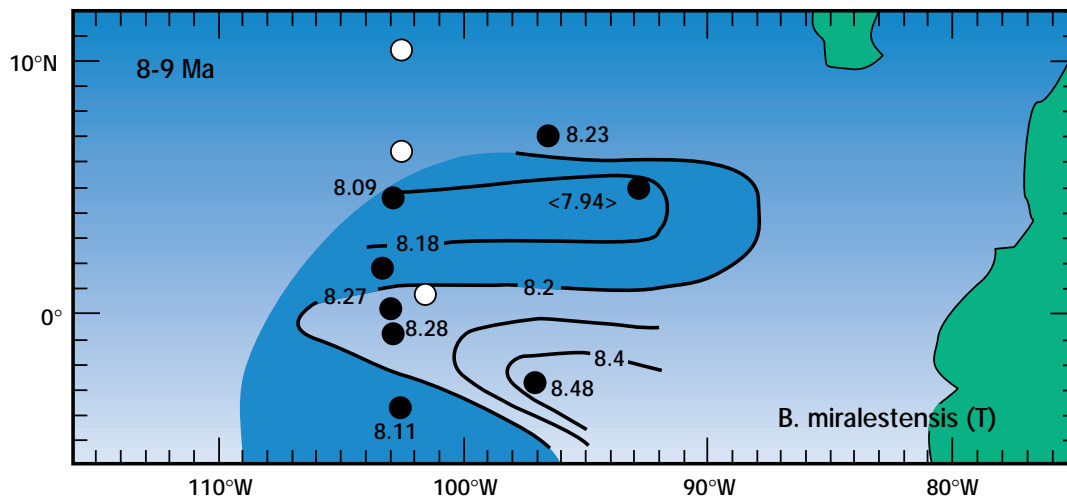
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Efforts aimed at tuning the geologic time scale to variations in Earth's orbit have taken us beyond the limits of radiometric dating and now allow us to make meaningful, quantitative estimates and comparisons of oceanographic processes taking place millions of years ago. An example of the usefulness of the orbitally tuned time scales is given by the ODP Leg 138 Sites in the eastern equatorial Pacific. The complete, orbitally tuned sections recovered on this leg have provided biostratigraphers with a high-resolution chronostratigraphic framework with which to define the first and last appearances of species at each site [Moore *et al.*, 1993]. The geographic distribution of the sites allows us to map both the timing and spatial patterns of invasion and extinction of species. These maps not only provide information on the process of evolution, migration, and extinction, they can also be related to water mass distributions and near-surface circulation and indicate shifts in circulation patterns through time. Maps of 28 diachronous radiolarian events (first or last appearances) studied at the 11 ODP Leg 138

sites have coherent spatial patterns that indicate shifts in the areas of high oceanographic gradients over the past 10 Ma. These changes in the locations of high gradient regions suggest that the South Equatorial Current was north of its present position prior to about 7 Ma. There was a southward shift in the northern boundary of this current between about 6 and 7 Ma, and the development of a relatively strong gradient between the northeastern and northwestern sites. This apparent shift in current boundaries is thought to be associated with the gradual cooling of the Northern Hemisphere. Between about 3.7 and 3.4 Ma, the steep gradients between the northeastern and northwestern sites were substantially diminished. This change is thought to be associated with the closing of the Isthmus of Panama.

References:

T. C. Moore, Jr., N. G. Pisias, and N. J. Shackleton, Paleooceanography and the Diachrony of Radiolarian Events in the Eastern Equatorial Pacific, *Paleoceanography*, 8(5), 567-586, 1993.



Timing of the last occurrence of *Botryostrobus miralestensis*. Blue shaded area indicates region of latest last occurrence in the areas outside the South Equatorial Current. Contour interval is 0.1 m.y. Numbers at each site give the median age of the event at that site. Numbers in brackets indicate events with a range of estimate greater than 0.1 m.y. Open symbols are shown at site locations where the event was not defined.