Late Eocene–Oligocene climatic and biotic evolution

Conveners
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With the current interest in mass extinctions, the dramatic climatic and faunal changes in the Eocene and Oligocene have garnered increased attention. New data have emerged from both the deep sea and from terrestrial sections, yet the geologists who work in these areas seldom attend the same meetings or read the same literature. To bring these people together, a Penrose Conference was held in Rapid City, South Dakota, August 1–5, 1989. More than 60 scientists participated, including three from Britain, three from France, two from Canada, and one each from Spain, West Germany, Australia, and New Zealand. On August 3, the group visited the classic Eocene and Oligocene exposures in Big Badlands National Park, where they examined the stratigraphic units, discussed the paleosols and newly completed magnetic correlations, and discovered land snails, turtles, and fossil mammals (including a titanothere in situ).

Subsequent to the Penrose Conference, a theme session on "Late Eocene–Oligocene Climatic and Biotic Evolution" at the Geological Society of America 1989 Annual Meeting included many of the same participants; specific data are included in Geological Society of America *Abstracts with Programs*, v. 21, p. A87–A89.

The Penrose Conference sessions, which were chaired by Don Prothero, began with an update of the changes in the chronological framework of the late Paleogene. Bill Berggren reviewed the recent data from the Italian Apennines, the Gulf Coast, and Wyoming and Nebraska which push the Eocene/Oligocene boundary to around 34.0–34.5 Ma, contrary to earlier estimates of 36.5 Ma (Berggren et al., 1985) or 32 Ma (Odin, 1982). The most radical new dates came from single-crystal laser-fusion $^{40}Ar/^{39}Ar$ dating done by Carl Swisher on volcanic ashes originally dated by K/Ar in 1964. The revised dates, magnetics, and biostratigraphy imply that the Uintan North American land mammal "age" is middle Eocene, the Duchesnean (40–37 Ma) and the Chadronian (34–37 Ma) are late Eocene (not early Oligocene, as the Chadronian was previously considered), and Orellan (32–34 Ma) and Whitneyan (29–32 Ma) are early Oligocene (not middle and late Oligocene).

The discussion then shifted to the global climatic evidence. Much of it has come from recent ODP drilling around Antarctica, as well as the CIROS I drilling project in the Ross Sea. The central issue was the timing and extent of glacial ice development during the late Paleogene, and the mechanisms for this cooling. Jim Kennett presented a model for warm saline deep waters during the Eocene, which were followed by surface-water cooling and development of cold bottom waters during the Oligocene. He was not convinced that significant ice sheets were developed until the middle Oligocene, although smaller glaciers may have been present before then. ODP Site 748 produced early Oligocene ice-rafted detritus as far north as 57°S, and Lou Bartek reviewed seismic and drilling data that suggest a major ice sheet grounded over the Ross Sea region by the middle Oligocene. Ken Miller pointed out that the oxygen isotope record reveals several sharp increases through the middle and late Eocene which could be due to either deep-water cooling or ice-volume increases. However, the oxygen isotope increase in the early Oligocene is definitely associated with an ice-volume increase and a lowering of sea level of 50–100 m. Another big isotopic increase and a major drop in sea level were probably triggered by a major ice-growth event in the middle Oligocene. Lisa Cirbus Sloan presented results of climatic modeling which showed that decreasing oceanic heat transport, influenced by changing ocean-bottom topography and oceanic circulation patterns, produced steeper temperature gradients and cooler sea surface temperatures, whereas changing land-sea distributions could not account for the cooling.

Catastrophists have argued that the presence of microtektites and iridium in some late Eocene sections suggests that the extinctions were caused by comets and/or asteroids. Joe Hazel did graphic correlations of sections with microtektite layers and argued that there were 6–9 of them in the late Eocene, spanning about 1.1 m.y. and not associated with mass extinctions. However, Gerta Keller and Norman MacLeod argued that the resolution of these correlated sections is insufficient to be able to distinguish that many layers, and only three are clearly distinct and well documented. All participants seemed to agree, however, that virtually none of the important extinction events are associated with microtektites, and that extraterrestrial factors played a relatively minor role, if any, compared to the massive climatic changes that were already taking place.

On the second day, conference participants reviewed the changes in marine floras and faunas. Gerta Keller pointed out that planktonic foraminifera undergo several steps of extinction and decreasing diversity, starting with the most important extinction at the end of the middle Eocene, and minor extinctions at the Eocene/Oligocene boundary. Marie-Pierre Aubry found a similar pattern in calcareous nannofossils: major extinction at the end of the middle Eocene, and then progressive decline of diversity and cooling through the late Eocene and Oligocene. Benthic organisms showed a similar pattern, punctuated by transgressions and regressions that affected the shelf on which they lived. This was true both of benthic foraminifera from Australia (McGowran) and the Gulf Coast (Thompson) and of benthic molluscs from the Pacific (Armentrout), Gulf Coast (Dockery), Atlantic (Ward), and Paris Basin (Dolin). Ewan Fordyce pointed out that diverse late Eocene archeocete whale faunas were replaced by toothed and baleen whales by the middle Oligocene, presumably in response to the oceanographic changes which created niches for filter-feeding in the early Oligocene.

After the mid-meeting field trip to the Badlands, the final two days focused on the terrestrial record. Gary Peterson and Charles Chapin both discussed the evidence of deep paleosols from the early and middle Eocene which indicate hot, humid conditions and protracted weathering; Chapin suggested that this might be due to slow spreading rates during Eocene plate reorganization, which decreased rates of uplift and topographic rejuvenation. Greg Retallack pointed out that paleosols in the High Plains show a trend from middle Eocene moist forests to middle Oligocene mixed

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grasslands. Margaret Collinson reviewed the floral evidence from both North America and Europe. As Jack Wolfe pointed out long ago, there are two major cooling events in land floras: one at the middle/late Eocene boundary, and one at the terminal Eocene event.

Several participants reviewed the climatic and faunal evidence from various parts of North America, including California and Oregon (Hanson), Canada (Storer), west Texas (Wilson, Runkel), Montana (Dawson, McKenna, Garcia, Tabrum, Hanneman), South Dakota (Bjork), and eastern Wyoming (Emry, Kron, Evanoff). The general consensus for North American land mammals was summarized by Lucas and Stucky: the greatest diversity was in the Uintan (middle Eocene), along with a great deal of endemism. Then, in the late Eocene (Duchesnean, about 40-41 Ma), diversity declined dramatically due to major extinctions and also to immigration of Asian forms. The Uintan/Duchesnean (middle/late Eocene) transition is truly the most fundamental one, and the extinctions in the late Eocene (Duchesnean/Chadronian) and at the Eocene/Oligocene boundary (Chadronian/Orellan) are much less important. The faunal elements present in the Duchesnean persist with only minor changes through the Chadronian, Orellan, and Arikareean. A similar story was given for mammals from Britain (Hooker), France (Hartenberger and Legendre), and central Europe (Heissig). Land snail faunas show similar changes in North America, although there is clearly a major drying event associated with the Chadronian/Orellan boundary, which dramatically affected the snails (Evanoff). Similarly, Howard Hutchinson showed that crocodilians and aquatic turtles declined throughout the late Eocene and virtually disappeared from the High Plains by the Orellan, leaving mostly land tortoises. Tortoise size changes indicate only slight declines in mean cold-month temperatures, but there was definitely an increase in aridity, resulting in loss of permanent streams and ponds by Orellan time.

Jim Swinehart and Richard Tedford reviewed the Whitneyan/Arikareean transition, which has been much confused in the past. New stratigraphic, magnetic, and Ar/Ar data show that the informally named "Brown Siltstone" which overlies the Whitney Member in Nebraska is temporally equivalent to the upper Poleslide Member and the Sharps Formation in South Dakota. Both are composed primarily of eolian volcaniclastics and are capped in Nebraska by the Gering Formation, which represents a period of fluvial valley-cutting in the late early Arikareean. However, the Whitneyan-Arikareean faunas are very low in diversity and consist mostly of inhabitants of interfluvial floodplains; they show no significant changes in response to the shift from eolian to fluvial deposition.

Two major themes emerged from the conference. Clearly, the Eocene/Oligocene extinctions were the product of a long-term (at least 7 m.y.) decline in climate, and extraterrestrial events (if they occurred) had virtually no effect that can be detected. Second, the most dramatic event is the middle/late Eocene (Bartonian/Priabonian, Uintan/Duchesnean, about 40-41 Ma) transition, which resulted in a major drop in diversity and turnover in both marine and terrestrial faunas and floras. Other extinction events (mid-Priabonian, terminal Eocene event, mid-Oligocene) were much less important, even though the terminal Eocene event has received all the attention in the past. Indeed, as Spencer Lucas pointed out, the natural break in the Cenozoic is between the middle and late Eocene, which he whimsically and informally named the "Eotoadstoolian" and "Toadstoolian." Judging from the rapid adoption of his terms, the participants in this conference found this distinction more natural than Eocene/Oligocene, Paleogene/Neogene, or other attempts to subdivide the Cenozoic into fundamental parts.

Conference Participants

John Armentrout
Marie-Pierre Aubry
Louis Bartek
William A. Berggren
Philip R. Bjork
Harold N. Bryant
Charles Chapin
Janet Coleman
Margaret E. Collinson
Mary Dawson
David Dockery
Luc Dolin
Robert J. Emry
Emmet Evanoff
John J. Flynn
R. Ewan Fordyce
Dan Garcia
Jonathan Goodmacher
Debra Hanneman
Bruce Hanson
Jan Hardenbol
Jean-Louis Hartenberger
Joe Hazel
Tim Heaton
Kurt Heissig
Jeremy J. Hooker
J. Howard Hutchinson
Gerta Keller
James P. Kennett
Don Kron
Rob Lander
John A. Larson
Serge Legendre
Spencer Lucas
Norman MacLeod
Paul Markwick
Brian McGowran
Bill McIntosh
Malcolm C. McKenna
Ken Miller
Eustoquio Molina
Gary Peterson
Donald R. Prothero
Jacques Renault
Greg Retallack
Tony Runkel
Rosalind Singer
Lisa Cirbus Sloan
Margaret S. Stevens
John Storer
Richard K. Stucky
Jim Swinehart
Carl Swisher
Alan Tabrum
Richard H. Tedford
Dennis O. Terry, Jr.
Peter Thompson
Lauck Ward
John A. Wilson
James C. Zachos

Future Penrose Conferences

Correlation of Nonmarine Cretaceous Strata, May 9-14, 1990, Breckenridge, Colorado. Information: Niall J. Mateer, Nonmarine Cretaceous Correlations, 1467 N. 17th, Laramie, WY 82070; (307) 721-4946.

Transpressional Tectonics of Convergent Plate Margins, August 25-30, 1990, Bellingham, Washington. Information: Vicki L. Hansen, Dept. of Geological Sciences, Southern Methodist University, Dallas, TX 75275-0395; (214) 692-4179.

Large Lakes and Their Stratigraphic Record, September 9-13, 1990, Lake Tahoe, California. Information: Andrew S. Cohen, Dept. of Geosciences, University of Arizona, Tucson, AZ 85721; (602) 621-4691 (direct), (602) 621-6024 (dept.).

New Methods for Dating of Geomorphic Surfaces, October 12-17, 1990, Mammoth Lakes, California. Information: Fred M. Phillips, Dept. of Geoscience, New Mexico Tech, Socorro, NM 87801; (505) 835-5540 (direct), (505) 835-5634 (dept.).

Predatory Dinosaurs of the World, a Complete Illustrated Guide

By Gregory S. Paul. 1988. Simon and Schuster, New York. 464 p. $22.95.

The public fascination with dinosaurs can be both a blessing and a curse to paleontologists. On the one hand, many of us started our careers with a childhood interest in dinosaurs, and dinosaurs produce most of the publicity for our profession. Indeed, without mentioning dinosaurs, it's often very hard to explain to a lay person how we differ from archeologists. On the other hand, dinosaurs so dominate our public image that less glamorous but more fundamental questions seldom get any notice. The mere mention of the word "dinosaur" in the title is sufficient to justify publication and generate sales for a popular book, no matter how poorly done.

There has always been a glut of amateurish books done mostly for children, but lately there have been a number of books intended for the "trade" audience. These books are written in lay language, published by a major company which distributes to most bookstores, and are often not subject to peer review. Most of these books concentrate on the more speculative aspects of dinosaurs, and so can be safely ignored by serious dinosaur scholars. Greg Paul's *Predatory Dinosaurs of the World*, however, goes beyond most popular books, both in the magnitude of its errors, and also in the headaches it will create for paleontologists.

For a "popular" book, it is written on a highly technical level that will be virtually impossible for a lay person to read. It is so full of Paul's jargon that it is very difficult for a specialist to read as well. (Just try struggling through Chapter 3; even if you know the taxa and localities, it's a chore). The sentences are very poorly written and constructed, and many do not have any connection to the preceding or following sentences. Some do not even have a verb (e.g., p. 61). In other places, he mixes metaphors in very strange ways (e.g., "theropod faunas that we can really sink our teeth into," p. 61). The spelling is atrocious. Virtually any word that is not in the dictionary (and therefore not checked by a copy editor) is likely to be misspelled, whether it is a location (Jord*o*n instead of Jord*a*n, Montana, p. 324), a name (McGow*e*n instead of McGow*a*n, p. 91), or a taxonomic term (examples too numerous to mention).

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More serious are the logical flaws in the book. Paul clearly knows a lot of anatomy, but he was not trained well enough to know the limitations of functional studies as well. Although he pays lip service to McGowan's cautions about functional studies (p. 93), he has clearly not taken it to heart. Not every muscle leaves visible evidence of its attachment to a bone! He was clearly not taught the difference between speculation and testable science, because he shows a complete disregard for accepted scientific standards of argumentation and evidence. His bald assertions and unwarranted extrapolations go on and on, page after page, without any supporting evidence or discussion of alternative interpretations. When he does mention an opposing point of view, he usually trivializes the argument without ever really addressing the point. For example, he dismisses Benton's arguments about therapsid—"thecodont" competition with a breezy statement that "this cannot be so because the two groups were out there squabbling over carcasses and competing for game" (p. 93). How does he know? Did he time travel back to the Triassic? These problems are particularly acute in his functional and behavioral interpretations (such as his imaginative description of dinosaur irises, for which we have no data, p. 99), which were critiqued by Crompton and Gatesy in the January 1989 *Scientific American*. Not surprisingly for a disciple of Bakker, he toes the hard-line view on dinosaur endothermy without ever really addressing the issue of the problems of heat disposal and food volumes in large-bodied dinosaurs, or the advantages of inertial homeothermy. Given his penchant for adopting every half-baked speculation on dinosaurs, he is surprisingly skeptical about the asteroid extinction model for the terminal Cretaceous event. Yet he negates this one bit of scientific caution when he invokes extraterrestrial catastrophes throughout the Triassic and Jurassic to explain extinctions in a way that would make even the most diehard catastrophist non-paleontologist blush.

But these kinds of errors are not unusual in popular dinosaur books, and they can usually be safely ignored by dinosaur specialists. The most serious problem with this book is that it makes a wide variety of taxonomic changes with little or no regard for the International Code of Zoological Nomenclature. There are many new taxa, from species to superorders, that are named without adequate diagnoses, or designation of types, or listing of referred specimens or taxa, or are otherwise unacceptable by the standards of the Code. These *nomina nuda* will have to be laboriously eliminated by all future theropod systematists, since they were published in a widely circulated medium that certainly would be considered available by the standards of the Code. Paul splits and synonymizes taxa with little or no justification, and presents no useful measurements or statistics to show just how similar or different they really are. In one instance, he names a new species (*"Aublysodon molnaris,"* p. 325) that is being described elsewhere by Atwater and Molnar, preempting the name before the original authors could publish their description.

His systematic philosophy might charitably be described as idiosyncratic. Although he has a superficial familiarity with cladistics, he shows that he does not understand its implications. For example, he shows a "cladogram" with no characters defining the nodes; when one tries to find the characters that support his taxonomic decisions, they are either vaguely defined and/or impossible to extract from the text. He creates a number of explicit taxonomic "grades," not only for basal wastebasket groups (e.g., "Paleodinosauria," "Paleotheropoda"), but even for taxa intermediate between primitive grades and advanced monophyletic taxa (e.g., "Intertheropoda"). He justifies his explicitly gradistic system because it contains equivalent rankings, as if a family of theropods were equivalent to a family in any other class! His criterion of a good system is one that "contains as much information as it can while remaining simple enough to grasp in a single good look," yet his confusing mix of grades and clades is demonstrably more difficult to interpret than a strictly phylogenetic classification, which lacks the arbitrary overprint of "morphological divergence."

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Many other problems could be mentioned, but these are the most serious. The numerous logical and spelling errors could have been caught by someone with minimal training in paleontology, so this book was either never reviewed or else the publisher paid no attention to the reviewers. This raises questions about the nature of unreviewed popular books in general. Should there be some standard of peer review applied to them as is applied to all journals in the field, since these books, often contain scientific content with serious repercussions? Unlike fiction and most trade books, scientific literature has an established minimal standard of quality that is independent of sales figures. Should scientists take an active role in protesting whenever publishers release a monstrosity like this? In this case, it is particularly sad that the book was commissioned by the New York Academy of Sciences, and bears its imprimatur. I wonder whether the New York Academy Board of Editors realized what kind of work their names would appear in.

The most frightening thing about the book, however, is the author's promise in the preface that he plans to do the rest of the Archosauria the same way! Let's hope that the New York Academy Board of Editors might be able to influence the publisher to submit future volumes to peer review, or at least limit their taxonomic content before they create a systematist's nightmare that will plague dinosaur scholars for years to come.

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