Penrose CONFERENCE

PENROSE CONFERENCE REPORT

The Marine Eocene-Oligocene Transition

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The Eocene-Oligocene transition was a critical period in Earth history, when the "greenhouse" climates of the Eocene were replaced by the "icehouse" conditions that persist today. In the past few years, new information has accumulated on this important interval of time, but understanding and synthesis have been hampered by lack of communication among various specialists. For this reason, we organized a Penrose Conference, "The Marine Eocene-Oligocene Transition," which was held August 17–22, 1999, at Evergreen State College in Olympia, Washington. Forty-seven scientists from the United States, Canada, Cuba, China, Japan, New Zealand, Germany, Belgium, and Hungary participated; among them were ten graduate students and four undergraduate students. Together we hoped to broaden our understanding of the changes associated with the transition from Eocene warmth to Oligocene glaciers from oceanographic, climatic, and paleontological perspectives. We addressed such questions as: What is the nature of change during the transition? Was it synchronous or diachronous? Were there discrete events or was the change protracted and cumulative? What was the nature of the extinctions at the end of the middle Eocene, and during the early Oligocene? Is there selectivity dependent upon latitude or ecology? How can we correlate and compare records?

Oceanic Record

The first day of the conference surveyed the Eocene-Oligocene marine record on a global basis, focusing on the pelagic and Antarctic record in particular. These are the best-studied records, and the growth of Antarctic glaciers is a critical factor in climatic change. Jim Kennett provided the keynote talk, reviewing our current understanding of Eocene-Oligocene climatic change. He pointed out that the Eocene-Oligocene cooling event was almost the mirror image of the Paleocene-Eocene warming event, with both long-term (millions of years) effects, due to plate tectonics (e.g., separation of Australia from Antarctica and development of the Circum-Antarctic current), and short-term events (rapid ice growth in the early Oligocene on a time scale of tens to thousands of years). Kennett suggested that clathrates (gas hydrates) might be a critical factor in short-term changes of the carbon reservoir and greenhouse gases, although the group felt that clathrates were probably more significant in the Paleocene-Eocene transition than during the Eocene-Oligocene transition.

The next few speakers examined the pelagic biotic record in detail. Paul Pearson and Hiroshi Nishi discussed the planktonic foraminifera; this group showed significant extinction at the end of the middle Eocene, and lesser extinction in the early Oligocene. However, revisions to foraminiferal taxonomy makes their extinction peaks less severe than specialists thought only ten years ago, because many pseudoextinctions have been eliminated. Etienne Steuerbaut gave an overview of the changes in the calcareous nannoplankton, which also showed significant extinctions at the end of the middle Eocene and in the early Oligocene, although many nannofossil datums are temperature-controlled and time-transgressive. Steve Schellenberg discussed the deep-sea ostracodes, which undergo a significant drop in diversity and decrease in biogeographic heterogeneity in the early Oligocene; they also suggest significant cooling at the end of the middle Eocene. According to Ewan Fordyce, the radiation of toothed and baleen whales must have occurred very rapidly in the early Oligocene, possibly in response to increased pelagic food resources with changes in oceanic circulation.

The Southern Ocean benthic record also indicates dramatic changes. Nancy Buening discussed the isotopic record of brachiopods from New Zealand, which experienced a dramatic temperature drop of 8–13 °C in the early Oligocene. Ellen Thomas and Liselotte Diester-Haass discussed the record of benthic foraminifers, focusing on the influence of trophic resources. In particular, the Oligocene shows increased productivity and benthic foraminiferal accumulation rates, possibly due to more vigorous circulation and increased nutrients compared to the sluggish, warm Eocene oceans. Steve Pekar examined the record of sea-level change, arguing that the evidence no longer supports the huge 130 m mid-Oligocene sea-level drop shown on the Exxon-Vail onlap-offlap curve, but that the early Oligocene ice-volume increase produced a 50 m eustatic sea-level fall, bigger than predicted in other sea-level curves. Finally, Paul Gammon described an incredible deposit of siliceous sponges along 2000 km of shoreline in southern Australia. It may indicate increased upwelling between Antarctica and Australia in the early Oligocene, or may also be due to increased silica delivery from continental weathering during early Oligocene cooler and wetter climates.

Pacific Rim

On the second day, the focus shifted to the record of the Pacific Rim, especially the northern Pacific basins now uplifted as coastal outcrops from California to Alaska and Kamchatka. This record has been underexploited in the past, because its correlation to the global time scale was so poorly known. Don Prothero reviewed the latest magnetostratigraphic studies of most of the key units in California, Oregon, and Washington. Enough sections have now been dated that their fossils can be compared to the global record on a finely resolved basis. Karen Wetmore did a comparison with the benthic foraminifers and found that they showed an overall decrease in diversity from the middle Eocene to early Oligocene. The next five speakers examined the excellent molluscan record recovered from Pacific Coast Eocene-Oligocene strata. Richard Squires presented a summary of his taxonomic review of gastropods, and found an overall decline in diversity from the late early Eocene maximum, with the biggest turnover in the early Oligocene, when Tethyan taxa were replaced by taxa from the north Pacific. Carole Hickman and Liz Nesbitt looked at the molluscan record of Oregon and Washington, respectively, and disagreed on when the maximal faunal turnover occurred. This may be an artifact of comparison between shallow- and deep-water faunas, which should be resolved soon now that correlation has improved. Louie Marincovich and Anton Oleinik discussed the molluscan record of Alaska and Kamchatka, respectively. Although detailed analysis and chronostratigraphy have not yet been done in these regions, they see a major increase in cool-water taxa in the early Oligocene, in agreement with the influx of similar taxa reported in California, Oregon, and Washington. Dave Scholl concluded the day by describing a remarkable 2-km-thick body known as the Meiji sediment drift, deep in

the ocean between the Emperor and Aleutian seamount chains. It implies the formation of cold, deep water out of the Bering Sea in the early Oligocene, suggesting that the Circum-Antarctic current and the North Atlantic Deep Water were not the only sources of cold bottom waters at that time.

Field Trip

As a mid-meeting break from the conference, we took a day trip on August 19 to two important Eocene-Oligocene localities in western Washington. In the morning, we visited the classic Eocene-Oligocene exposures of the Lincoln Creek Formation at Porter Bluffs, near the towns of Porter and Malone. The entire group walked along the roadcuts collecting fossils, and got a good chance to see the kinds of exposures and fossils that typify the marine Eocene-Oligocene of the Pacific Northwest. After a leisurely lunch stop at the mysterious Mima Mounds, we drove down to Longview, Washington, and visited the famous exposures of the middle Eocene Cowlitz Formation at Coal Creek. The creek level was very low, so the entire group had excellent collecting at several levels in the formation, including a dense oyster bed more than 1 m thick that crosses the creek.

Atlantic, Gulf, and Tethyan Record

During the final two days, attendees reviewed the evidence from the Atlantic margin, including the Gulf, Caribbean, North Sea, Tethys, and Paratethys. Ernie Mancini opened the Gulf Coast discussion with a review of the stratigraphy. Linda Ivany then described isotopic studies of the otoliths of conger eels, which preserve a detailed record of bottom-water conditions. She found little evidence of long-term temperature change from the middle Eocene to the Oligocene, suggesting that ice volume may be more important to the global isotopic shift, but there was evidence of greater seasonality in the Oligocene. Tom Yancey and Francisca Oboh-Ikuenobe looked at Gulf Coast pollen, finding significant evidence of long-term cooling and drying. Rick Fluegeman summarized the Gulf Coast benthic foraminifera, and noted that the major diversity change occurs in the early Oligocene. Burt Carter discussed the echinoid record, which is highly controlled by facies patterns so overall trends are difficult to discern; nevertheless, there is a big drop in diversity across all habitats in the early Oligocene. David Dockery, and Dave and Matt Campbell reviewed the molluscan record in the Gulf and Atlantic regions. Like other workers, they found the highest diversity in the middle Eocene, and major extinctions at the end of the middle Eocene, and especially in the early Oligocene. Rowan Lockwood looked at the venerid clams in greater detail; she found that the survivors of these extinctions had shapes adapted for more rapid burrowing ability. According to Earl Manning, the Gulf Coast vertebrate record shows relatively few changes in the diversity of sharks and other marine vertebrates (except for the extinction of archaeocete whales and giant sea snakes). Manuel Iturralde-Vinent provided a provocative synthesis of the Cenozoic paleogeography of the Caribbean, suggesting that the restricted subtropical flow in the Eocene was replaced by more open circumtropical current in the Oligocene.

The final day began with a review of climatic modeling of the Eocene by Karen Bice. She touched on a number of the points raised by earlier presenters, and suggested how they were or were not compatible with the current generation of climatic models. Noel Vandenberghe then reviewed the record of the North Sea, and Miklos Kazmer the Paratethys, regions that were very sensitive to changes in the faunal composition and temperature of the tropical Tethyan seaway to the south. The final three talks (Wylie Poag, Yin Yanhong, and Jim Whitehead) focused on the well-documented impacts that occurred in the middle late Eocene (35.5–36.0 Ma), primarily at the Popigai crater in Siberia, and the crater beneath Chesapeake Bay. Although these impacts were almost as large as that of the K-T, it is now well documented that they caused no extinctions of significance, a point driven home by many of the speakers. This casts serious doubt on the suggestion that all major impacts cause extinctions. However, Wylie Poag suggested that the latest Eocene reversals in the cooling trend might be a long-term effect of the impacts.

The meeting concluded with a free-form discussion about a variety of topics by all the participants. In our final afternoon, the group reached the following conclusions: (1) the earliest Oligocene isotopic event is real and globally synchronous, and mostly caused by ice volume (some regions show limited cooling); (2) the opening and closing of gateways to oceanic circulation played a key role in climatic change; (3) major faunal turnover is associated with both the end of the middle Eocene (37 Ma) cooling, and the early Oligocene glaciation (33 Ma); (4) extinctions were earlier and more severe at higher latitudes; and (5) the extraterrestrial impacts in the middle late Eocene had no obvious effect on life.

By the end of the meeting, it was very clear that the interest level, excitement, and morale of the participants were very high, and we were all eager to learn more and make further connections. This momentum is now maintained by a Web site (www.washington.edu/burkemuseum/paleo.html, click on Geology and look in the Invertebrate Fossils section). Many participants started new collaborations that should lead to important new discoveries and interdisciplinary projects.

Acknowledgments

We thank the staff at Evergreen State College for providing a splendid venue for our conference, and Lois Elms of Western Experience for handling the logistics of the meeting. We thank the Penrose Conference Fund of the Geological Society of America for help funding student participants. ■

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