

 PROFILE

# Profile of Paul E. Olsen

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Geologist Paul E. Olsen follows a simple guiding principle: obtain information from the geological record that is not available from other sources. Doing so has enabled Olsen, a professor of earth and environmental sciences at the Lamont–Doherty Earth Observatory of Columbia University (LDEO), to illuminate the history of the Solar System and evolution of continental ecosystems. Olsen, who was elected to the National Academy of Sciences in 2008, recovered a climate cyclicity record spanning 30 million years and discovered the largest North American vertebrate fossil assemblage at the Triassic–Jurassic boundary. His latest project is The Geological Orrery, a network of early Mesozoic geological records of orbitally paced climate that could lead to fundamental insights into physical processes of the Solar System.



Paul E. Olsen. Image courtesy of Kevin Krajick (Columbia University, New York).

## Presidential Commendation

Olsen was born in New York City in 1953, but after a series of moves he and his family settled in Livingston, New Jersey. Olsen says, “I was one of those awkward kids who knew all the names of the dinosaurs described in children’s and young readers’ books of the 1950s and was happy to tell anyone all about them.” When he learned that another Livingston resident, Silvio Crespo, Jr., found dinosaur footprints in the summer of 1968 at nearby Riker Hill on what was then the Roseland Quarry, he and friend Anthony Lessa hiked 1.5 miles to the site.

There, they met amateur paleontologist Robert Salkin, who introduced them to vertebrate paleontologist Donald Baird, then at Princeton University, and Bobb Schaeffer, a curator and Triassic fish expert at the American Museum of Natural History. Baird facilitated a meeting with Princeton sedimentologist Franklyn Van Houten, who had interpreted the alternating gray and red layers of older strata in the Newark Basin as being paced by variations in Earth’s orbit. The patterns intrigued Olsen, who delved into the topic.

Salkin, Olsen, and Lessa launched a campaign to preserve the Riker Hill tracks, holding public meetings and giving lectures. Following Salkin’s advice, Olsen wrote letters to then US President Richard Nixon, asking for support. The quarry’s landowner donated

much of the property, later featured in a *Life* magazine story, “With a little help from two friends, the dinosaurs finally win one” (1). For their work related to the tracks, Lessa and Olsen received presidential commendations in January 1971. The Riker Hill Fossil Site was declared a National Natural Landmark in June of that year.

## Overcoming Challenges

Notwithstanding early fame, Olsen had math and writing phobias; he graduated in the middle of his Livingston High School senior class. Salkin protégé Kenneth Rose, a vertebrate paleontologist who was then a Yale University undergraduate, saw Olsen’s potential and gave him a Yale tour. Olsen applied to the university and was admitted in 1971. He says, “I was supposed to graduate in the class of 1975, but it took me 7 years instead of 4. I was struggling at Yale, undisciplined as I was and completely distracted by the Yale Peabody Museum of Natural History fossil collections and fieldwork.” He took time off for research after his sophomore year, and again later, after his junior year because his father’s construction business collapsed during the 1973–1975 recession. During the latter hiatus, another mentor, Keith Stewart

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See companion article on page 10664.

This is a Profile of a member of the National Academy of Sciences to accompany the member’s Contributed Article, 10.1073/pnas.1813901116.

Published online March 4, 2019.

Thomson, paid Olsen to do fossil collecting, provided encouragement and, along with several of Thomson's graduate students, helped Olsen to overcome his math and writing fears.

When he returned to Yale in the spring of 1978, Olsen had already authored several articles, including two in the journal *Science*. The first article presented evidence that many terrestrial vertebrate fossil sequences thought to be of Late Triassic age were actually from the Early Jurassic (2). The findings narrowed the window for the timing of the end-Triassic mass extinction, and debunked the assumption that global fossil gaps exist at geologic period boundaries. The second article documented cyclic changes in a Late Triassic lake and shore assemblage that included the best-preserved insect remains known for that period (3). The work evidenced Olsen's growing understanding of Milankovitch-paced lake strata. Milankovitch cycles describe the collective effects on climate over time of Earth's eccentricity, axial tilt, and precession. For this and other achievements, Olsen received the Thomas Jefferson Medal for Outstanding Contributions to Natural Science in 2015.

Olsen remained at Yale for his graduate studies. Geologist Robert Berner provided access to his laboratory, where Olsen conducted his first quantitative geochemical measurements. Geochemist Karl Turekian was another mentor at Yale. Turekian introduced Olsen to LDEO geochemist Wallace Broecker. With Broecker's support, and after a year-long postdoctoral stint at the University of California, Berkeley's Miller Institute of Basic Research in Science, Olsen accepted a position as assistant professor of geological sciences at LDEO in 1984, gradually rising through the ranks to professor. Olsen also became a research associate at the Virginia Natural History Museum and the American Museum of Natural History, positions that he still holds. At LDEO, geologist James Hays was Olsen's entry mentor, and Dennis Kent, head of LDEO's paleomagnetism laboratory, deeply influenced Olsen, honing his ability to perform geological experiments.

### Dawn of the Dinosaur Age

Olsen and his colleagues have discovered numerous significant Mesozoic remains and tracks. In 1986, Olsen, working with Baird, used a cladistic approach to the study of fossilized footprints, enabling identification of the dinosaur-like ichnotaxon *Atreipus* (4). The Late Triassic tracks have since been found nearly globally and belong to forms close to the stem of the dinosaur family tree. With evolutionary biologist Neil Shubin, Olsen also co-led the discovery of the largest North American vertebrate fossil assemblage at the Triassic–Jurassic boundary (5). The 200-million-year-old fossils include Canada's earliest known dinosaur remains. Subsequent analysis by Olsen and his team concluded that the finds are consistent with a global extinction event at the Triassic–Jurassic boundary because fossils of common Triassic species are absent from the assemblages (6).

As for the likely cause of the mass extinction, Olsen and colleagues identified an iridium anomaly at the

Triassic–Jurassic boundary (7). They initially ascribed the extinction to an asteroid impact, as suggested by the iridium anomaly at the Cretaceous–Tertiary boundary. Olsen and his team later revised their assessment after analysis of new zircon uranium–lead chronology data and the discovery of multiple iridium anomalies (8). The findings permitted linkage of the extinction event to the Central Atlantic Magmatic Province. A series of volcanic eruptions known to have begun ~200 million years ago, the Central Atlantic Magmatic Province released an estimated 2.5 million cubic miles of lava over a 600,000-year period. Olsen and his team theorize that resulting climate change could have led to extinctions that caused ecosystem voids, which were later filled by dinosaurs.

### Coring Projects

Olsen has also performed work on Fourier analysis, a technique that transforms geological patterns into quantified wave functions that may be used to glean clues to possible causes. Olsen first used the method to reconstruct a 40-million-year lake record of periodic climate changes controlled by variations in Earth's orbit (9). The changes, identified within Late Triassic formations of the Newark Basin, suggested at the broadest scale that orbital cycles of 200 million years ago were not different from current cycles. Olsen says, "This paper was key to the 1989 proposal to core the full Newark Basin Triassic age record." The Newark supergroup includes both the Newark Basin and the Hartford Basin of Connecticut and Massachusetts.

With a \$2.1 million grant from the National Science Foundation, Olsen and his team collected nearly 22,600 feet of continuous core from seven sites within the supergroup. The cores provide an unprecedented record of 30 million years of cyclical climate change in strata that formed in a tropical continental setting of the ice-free world of Late Triassic Pangea. They now serve as a baseline against which climate-change models are compared. While the record was consistent with overall Milankovitch periodicities in the paleotropics (10), there were some differences that hinted at Solar System chaos—the erratic orbits of Earth and other celestial bodies over long periods due to factors such as overlapping resonances—previously predicted by theory.

To explore this possibility and to study early Mesozoic biotic and environmental change, Olsen and his team embarked on the Colorado Plateau Coring Project (CPCP) in November 2013 (11). Phase I of CPCP was completed a month later. The project involved drilling a 1,640-foot-long core through the Triassic section of Arizona's Petrified Forest National Park.

### Geological Expressions of the Solar System

Olsen is using the cores to uncover long-term behavior of the planets. With Dennis Kent, he observed a difference between the modern Mars–Earth eccentricity cycle of 2.4 million years and the 1.75-million-year cycle present in the Newark Basin core (12). The article identified geological expression of Solar System chaos and marks an attempt to resolve the secular frequencies of the perihelion of the inner planets from

geological data. The frequencies were previously only known from numerical calculations.

Olsen's more recent work reports a proof-of-concept for The Geological Orrery (13). Olsen says, "This paper demonstrates the extremely high-quality quantitative data on planetary orbits that can be obtained from the geological records of climate from hundreds of millions of years in the past, using a well-planned set of coring experiments in the right geological environments and with absolutely minimal data manipulation." Data from the network could provide an empirical way to constrain the chaotic history of the Solar System.

Olsen's current projects reflect the breadth of his interests and ambition. He is planning a workshop for

CPCP phase II, which will involve obtaining a long record of climate change from high latitudes that will be contemporaneous with the Newark–Hartford record. His team is also investigating the Carnian Pluvial, an early Late Triassic episode of increased humidity; trends of planetary motion; an amplification of the hydrological cycle that occurred during the early Mesozoic; and end-Triassic extinction causes and effects. Olsen is also writing his first book. He says, "The book will describe the incredible fossil footprint record of the Triassic and Jurassic in eastern North America and what it means for the evolution and ecological ascent of the dinosaurs and our modern world."

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- 1 Gore R, Ray W (1970) With a little help from two friends the dinosaurs finally win one. *Life Magazine*, December 11:73–74.
  - 2 Olsen PE, Galton PM (1977) Triassic-Jurassic tetrapod extinctions: Are they real? *Science* 197:983–986.
  - 3 Olsen PE, Remington CL, Cornet B, Thomson KS (1978) Cyclic change in late Triassic lacustrine communities. *Science* 201:729–733.
  - 4 Olsen PE, Baird D (1986) The ichnogenus *Atreipus* and its significance for Triassic biostratigraphy. *The Beginning of the Age of Dinosaurs, Faunal Changes Across the Triassic Jurassic Boundary*, ed Padian K (Cambridge Univ Press, New York), pp 61–87.
  - 5 Olsen PE (1986) Discovery of earliest Jurassic reptile assemblage from Nova Scotia implies catastrophic end to Triassic. *Lamont (Newsletter)* 12:1–3.
  - 6 Olsen PE, Shubin NH, Anders MH (1987) New early Jurassic tetrapod assemblages constrain Triassic-Jurassic tetrapod extinction event. *Science* 237:1025–1029.
  - 7 Olsen PE, et al. (2002) Ascent of dinosaurs linked to an iridium anomaly at the Triassic-Jurassic boundary. *Science* 296:1305–1307.
  - 8 Blackburn TJ, et al. (2013) Zircon U-Pb geochronology links the end-Triassic extinction with the Central Atlantic Magmatic Province. *Science* 340:941–945.
  - 9 Olsen PE (1986) A 40-million-year lake record of early Mesozoic orbital climatic forcing. *Science* 234:842–848.
  - 10 Olsen PE, Kent DV (1996) Milankovitch climate forcing in the tropics of Pangea during the Late Triassic. *Palaeogeogr Palaeoclimatol Palaeoecol* 122:1–26.
  - 11 Irmis R, et al. (2017) The Colorado Plateau Coring Project: A Continuous Cored Non-Marine Record of Early Mesozoic Environmental and Biotic Change. European Geosciences Union General Assembly 2017, Paper EGU2017-14923.
  - 12 Olsen PE, Kent DV (1999) Long-period Milankovitch cycles from the Late Triassic and Early Jurassic of eastern North America and their implications for the calibration of the Early Mesozoic time scale and the long-term behavior of the planets. *Phil Trans R Soc Lond* 357:1761–1787.
  - 13 Olsen PE, et al. (2018) Mapping Solar System chaos with the Geological Orrery. *Proc Natl Acad Sci USA* 116:10664–10673.