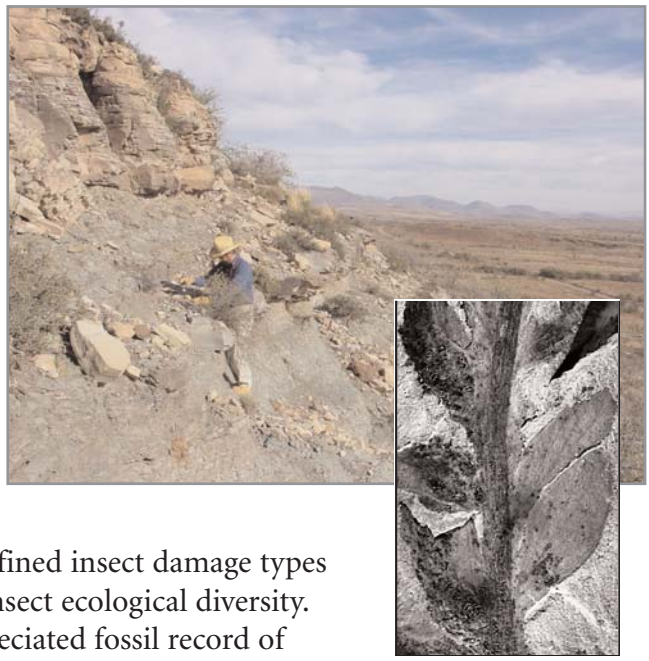
Patterns of Terrestrial Ecosystem Recovery from the Permian-Triassic Extinction of the Karoo Basin in South Africa

Plants and Insects

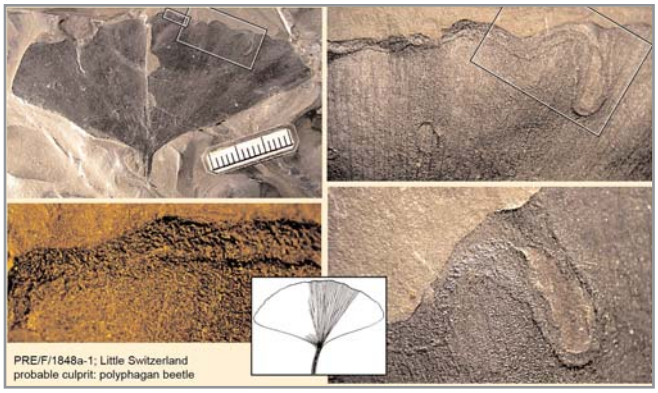
Plants and insects, the two most diverse macroscopic groups of organisms, have long been associated. As early as the Devonian Period (410 million years ago), fossil evidence shows that insects used plants, primarily through external stem feeding and spore consumption. The ways in which insects used plants has increased over time, shifting from mostly leaf chewing to include piercing-and-sucking, galling, and leaf mining.

Dr. Conrad Labandeira, research scientist and curator of fossil arthropods in the Department of Paleobiology at the Smithsonian National Museum of Natural History, studies the associations between plants and insect herbivores to better understand the diversity and evolution of these groups of organisms.



Mite galls on seed fern *Dicroidium crassinervis* (Corystospermales: Umkomasaceae)

Recording presence-absence data in the fossil record for explicitly-defined insect damage types is crucial for understanding the effect of mass extinction events on insect ecological diversity. For insect-mediated damage on plants, there is a rich and underappreciated fossil record of plant fossils that is considerably more abundant and preservationally complete than that of insects themselves, particularly at extinction intervals.



Leaf mine on *Paraginkgo antarctica* (Saporta) Anderson & Anderson (Ginkgoales: Ginkgoaceae). Late Triassic (~225 Ma) Molteno Formation; Karoo Basin, South Africa. See bar on timeline at right.

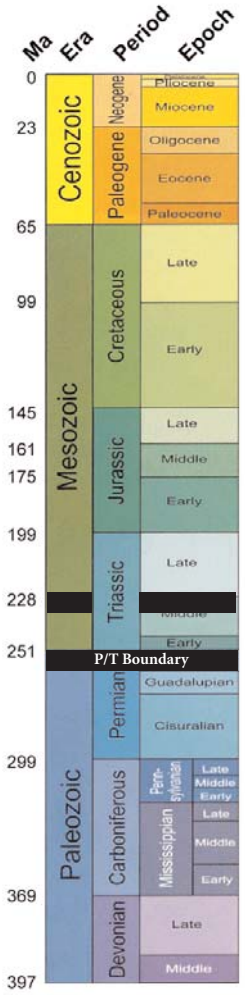
Dr. Labandeira collecting plant fossils from the Karoo Basin.

Mass Extinction: The P/T Boundary

The earlier Permian Period of the Paleozoic Era occurred 299-252 million years ago. The Triassic Period of the Mesozoic Era occurred 251-200 million years ago.

The end of the Permian (P/T) was marked by the greatest mass extinction of the last 600 million years of Earth history, during which perhaps 96% of species disappeared. Nearly 90% of marine species and 65% of reptile species went extinct at this time. Insects also suffered their greatest mass extinction in Earth's history.

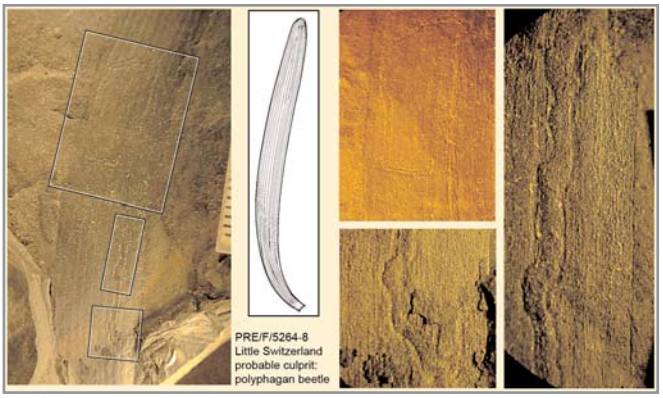
The P/T boundary provides significant fossil evidence of insect-plant interactions before and after the extinction. The distrubution of distinct damage types above and below the boundary provides a pattern in which Permian herbivorous insects were largely consuming leaves from the outside, whereas Triassic species were partitioning plant tissues from within, typically as leaf miners, gallers, and seed predators.



Karoo Basin of South Africa

The Karoo Basin covers nearly two-thirds of South Africa and provides an unmatched record of evolving paleoenvironments during which changes in biodiversity occurred. Scientists study the fossil record of this basin because of it represents globally the most complete Permian-Jurassic sequence for a land-based deposit. Although similar geological successions are present in India, China, and Russia, they are not as complete.

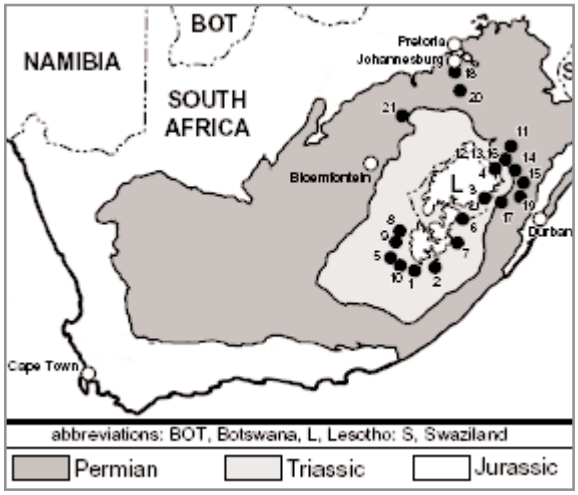
In particular, the Karoo Basin provides an ideal site for scientists to collect fossils from a 45-million-year interval spanning the Permian/Triassic (P/T) boundary, which marks a mass extinction 251 million years ago. The P/T boundary provides fossil evidence for insect-plant interactions before and after this greatest of extinctions. Comparing fossil plant remains from numerous localities of the Karoo allows scientists to better understand how plants and insects were impacted by the extinction and how they rediversified during the subsequent Triassic Period.



Leaf mine on *Heidiphyllum elongatum* (Morris) Retallack (Voltziales: Voltziaceae). Late Triassic (~225 Ma) Molteno Formation; Karoo Basin, South Africa. See timeline on previous page.

Seed predation on *Avatia* (Ginkgoales)(Birds River)

Dr. Labandeira received a small grant from NMNH to aid his study of patterns of extinction and recovery in terrestrial ecosystems from the Karoo Basin of South Africa. He partners with scientists in the United States, South Africa and the Netherlands to quantify within-community plant diversity and insect herbivore damage using data from field censuses and by studying plant-macrofossil collections at partnering institutions.

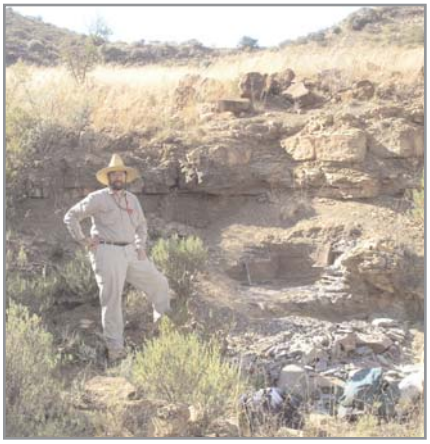


Major geological strata of the Karoo Basin.

Dr. Conrad Labandeira

Conrad Labandeira was born and raised in the San Joaquin Valley of central California. While helping his family tend the crops on their 30-acre farm, Conrad's interest in insects and their effects on plants was founded.

Conrad attended undergraduate school at California State University, Fresno, where he received a bachelor's degree in 1980 as a triple major in biology, geology and anthropology. He received his Masters degree from the University of Wisconsin, Milwaukee, and went on to receive his Ph.D. from the University of Chicago. His dissertation focused on a morphologic (phenetic) classification of recent insect mouthparts, and the application of this classification to the phylogeny of insects in order to determine the history of insect dietary guilds and functional feeding-groups.



Conrad joined the Department of Paleobiology at the National Museum of Natural History in 1992. His research has focused primarily on plant-insect associations in the fossil record, insect paleoecology and the evolution of terrestrial ecosystems. He actively researches sites in Colorado, Wyoming, Montana, North Dakota, Kansas, Nebraska, Québec, Argentina and South Africa.

For more information about the Department of Paleobiology, please visit www.mnh.si.edu/paleo.

The National Museum of Natural History provides small grants annually to its scientists to support their research and collections. In 2005, more than 40 scientists received a small grant. Donations made to the NMNH Annual Fund make the Small Grants Program possible.

Smithsonian
National Museum of Natural History

Office of Development
PO Box 37012 MRC 135
Washington, DC 20013-7012
202-633-0821
nhdevelopment@si.edu