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Spotlight on Science at the Smithsonian

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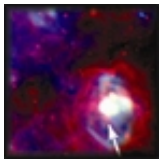
- Introduction from Dr. David Evans, Smithsonian Under Secretary for Science



- The Supernova Problem

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Spotlight on Science at the Smithsonian is a bi-weekly electronic newsletter about Science at the Smithsonian. It is produced for the Smithsonian community by the Office of the Under Secretary for Science. To subscribe to the newsletter or Podcast, visit science.si.edu.

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Introduction from the Under Secretary for Science

In this installment of Spotlight on Science, we'll start by looking at the remnants of supernova—the result of exploding stars. Researchers at the Smithsonian Astrophysical Observatory are using radio and infrared images to find supernova remnants. Back on Earth, we'll look at research performed in South Africa's Karoo Basin. Smithsonian scientists are examining fossil records there to better understand the Permian/Triassic extinction. This massive extinction resulted in the disappearance of up to 96% of all living species. In a study of plant fossils from South America, Smithsonian researchers are examining the effect that climate change may have on the size of forests and overall plant diversity. Finally, we'll look at research tracking the movement of sand dunes in California's Ibex Valley. This research updates a classic 2-dimensional tracking of sand dunes into 3-dimensions, through the use of measurements from a highly-accurate differential global positioning system.

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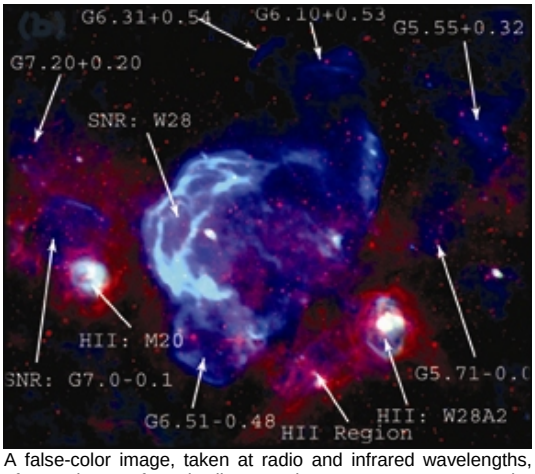

A false-color image, taken at radio and infrared wavelengths, of one cluster of newly discovered supernova remnants. The new objects are labeled with a "G" designation that includes their galactic coordinates; previously known SNRs are also labeled, as are bright knots of ionized gas known as "HII Regions."

The Supernova Problem

Some stars, very massive ones for example, end their lives in supernova explosions. All that is left behind from such a supernova is a diffuse, faint bubble of hot gas called a supernova remnant (SNR) and perhaps a very compact ember of material in the form of a neutron star or black hole. Supernovae are interesting to astronomers for several reasons. First, they disperse into the cosmos all of the elements spawned inside their progenitor stars (i.e., most of the elements above helium in the periodic table). Also, they can be used as "standard candles" to estimate cosmic distances. Finally, they tell the story of the end of some stars' lives. The current understanding of stars and supernovae suggests there ought to be over a thousand SNRs in our Milky Way galaxy, but only about 231 are known. Astronomers are therefore anxious to know whether this dearth reflects some misunderstanding about SNRs or is simply the result of the inadequate sensitivity of the searches that have been made looking for them.

A new search for supernova remnants has discovered thirty-five new ones in one region of the sky, increasing the total number of known SNRs in our galaxy by 15% and strongly suggesting (if every section of the sky likewise harbors a similar fraction of SNRs) that the current ideas about SNR are correct. A team of five astronomers including Center for Astrophysics astronomer Bryan Gaensler and student Joseph Gelfand used radio and infrared images to detect the new objects situated in the midst of bright background nebulosity; their survey probed much deeper than previous searches in that part of the sky. The newly discovered objects not only provide reassuring confirmation that current thinking about supernovae is accurate, they offer other insights as well. For example, it is thought that massive stars form in clusters, and the newly discovered SNRs themselves appear to be clustered together just as they would be if their progenitor stars formed together and stayed together during their lifetimes.

Reference

C. Brogan, *et al*., "Discovery of 35 New Supernova Remnants in the Inner Galaxy," 2006, *The Astrophysical Journal Letters*, **639**, L25.

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Conrad Labandeira working in the Wapadsberg Locality in the Karoo Basin.

Permian/Triassic Mass Extinction

Reference

Robert A. Gastaldo, Rose Adendorff, Marion Bamford, Conrad C. Labandeira, Johann Neveling, and Hallie Sims. "Taphonic Trends of Macrofloral Assemblages Across the Permian-Triassic Boundary, Karoo Basic, South Africa," 2005, *Palaios* **20**(**5**):479-497.

The Permian/Triassic Boundary (P/Tr) was marked by the greatest mass extinction of the last 600 million years of Earth history. During this extinction up to 96% of species disappeared. Nearly 90% of marine species and 65% of reptile species went extinct. Insects also suffered their greatest mass extinction in Earth's history. The events may have varied regionally in magnitude and timing, and the effects on land may not coincide with the effects in the oceans.

In order to further understand the loss of terrestrial diversity at this critical time, Museum of Natural History scientist, Conrad Labandeira and colleagues examined plant fossils in South Africa's Karoo Basin. The Karoo Basin covers nearly two-thirds of South Africa and provides an ideal site for scientists to collect fossils from a 45-million-year interval spanning the P/Tr. Comparing fossil plant remains from numerous sites in the Karoo Basin allows scientists to better understand how plants, insects and especially their associations were impacted by the extinction. It also provides insight into how they rediversified during the subsequent Triassic Period.

For the past 5 years Labandeira has done field work in the Karoo Basin. He has also evaluated plant-insect associations from earlier field collections at the University of the Witswatersrand in Johannesburg for Permian material, and at the South African National Biodiversity Institute in Pretoria for Triassic material.

His recently published paper presents a record of the outcome of the physical, chemical, and biological processes that operated within the Karoo basin at the P/Tr. It concludes that the changing landscape through time had a definite preservational effect on which plant assemblages became fossilized and therefore care must be taken when drawing conclusions about extinction based on surviving fossil assemblages.

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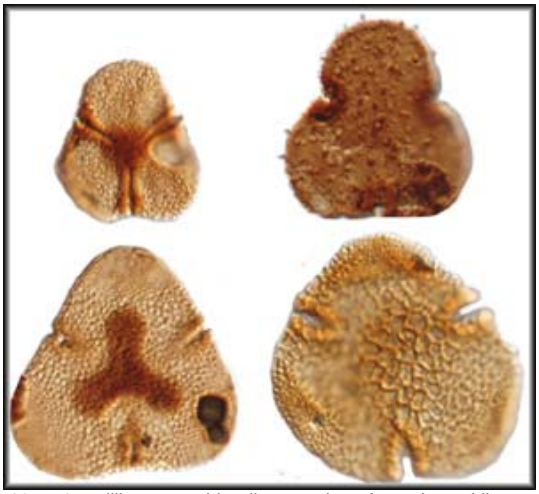

20 to 65 million year old pollen species of *Bombacacidites*, a fossil related to the Bombax family.

Neotropical Plant Diversity

The tropical rainforests of South America have extremely high plant diversity. Tracking the evolution of neotropical plant diversity has been difficult due to the limited fossil record. In order to further understanding of the plant diversity, Smithsonian Tropical Research Institute scientist Carlos Jaramillo and his colleagues compiled data of the fossil pollen record from 65 to 20 million years ago (the Paleocene to the early Miocene). The pollen record was then correlated with global temperature estimates.

Using samples from central Colombia and western Venezuela, the study analyzed pollen and spore content to determine floral diversity over time. The Paleocene had low diversity, which greatly increased through the middle Eocene and then decreased again through the early Oligocene. This was followed by another spike in diversity and decline from the middle Oligocene to the early Miocene. This overall pattern corresponds well to the trends in global temperatures over the same time period.

Species diversity tends to increase with warmer global temperatures and decrease as the planet cools. This affects the tropics even though the local average temperature in the tropics does not change much. Episodes of global warming have correlated with an increase in the area of tropical climates and global cooling has led to shrinkage of tropical area, thereby decreasing species diversity. These results are published in the 31 March 2006 issue of *Science.*

These findings suggest that the size of the forested areas strongly influences plant biodiversity in the neotropics. Conservation efforts which provide isolated pockets of rainforest to be protected while allowing continued destruction and fragmentation may not be enough to prevent long term declines in biodiversity.

Reference

Carlos Jaramillo, Milton J.Rueda and German Mora, “Cenozoic Plant Diversity in the Neotropics,” 2006, *Science*. **311(5769):** 1832-1896.

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Smithsonian researchers track the shifting position of sand dunes over time.

Monitoring Shifting Sands

The occurrence of sand dunes on Earth is not a unique circumstance; they have also been detected on Mars and recently on Titan, a moon of Saturn. To understand the processes that lead to their formation, researchers at the National Air and Space Museum's Center for Earth and Planetary Studies (CEPS) are monitoring subtle changes taking place in a series of star dunes in California near Death Valley.

Sand dunes that have three or more arms branching from the central dune mass are called star dunes. They tend to form where strong winds blow across the region from multiple directions. The combination of pristine, active dunes within a protected area and the precision Differential Global Positioning System (DGPS) capabilities now available make the Ibex Dunes an excellent location to document the variability of sand movement on dunes. DGPS allows researchers to measure precise real-time positional information. By occupying a fixed reference point during each trip, they were able to document the three-dimensional location of the crests along the arms of the sand dunes. One particular dune was surveyed previously using older DGPS equipment (involving post-processing instead of real-time data techniques), so that we can now see how that dune has changed over a time span of nearly three years.

The new monitoring techniques allow the scientists to evaluate the summit of a dune that has now been surveyed on three time points with time and position accuracy in a remote location. The summit of this dune shifted 4.24 m WSW and rose 0.53 m from 2/20/03 to 1/6/05, then shifted 5.49 m NNE and rose another 0.74 m from 1/6/05 to 11/17/05. Annual resurveying of the Ibex dunes is planned to continue to monitor changes.

Sand movement studies help us to understand the processes that shape the Earth. Further research relating the changes in the dune position and shape to storm winds is planned.

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