NORTHWESTERN ENGINEERING AND FIELD MUSEUM COLLABORATIONS

SPAN PREHISTORIC EARTH TO THE MOON

Northwestern Engineering professors have long enjoyed strong collaborative ties with researchers at the Field Museum in Chicago. Two recent projects, one at the intersection of analytical materials science and cosmochemistry, and another blending design and paleobiology to promote children's interest in science, highlight the interdisciplinary, evolving teamwork between the institutions.

Photo courtesy of the NASA Image and Video Library

AN UP-CLOSE LOOK AT FAR-OUT MATERIALS

In 1972, when NASA's Apollo 17 astronaut crew returned home from the space agency's final crewed mission to the Moon, they brought with them 250 pounds of rocks and soil from the lunar surface.

For nearly 50 years, scientists have had to balance preservation of this scarce resource with a natural curiosity to study the material in hopes of uncovering new insights about the Moon and our solar system.

When Philipp Heck, Robert A. Pritzker Curator for Meteoritics and Polar Studies and head of the Robert A. Pritzker Center at the Field Museum, and Jennika Greer, a resident graduate student at the Field Museum, gained access to a sample of lunar soil in 2019, they turned to Northwestern Engineering materials scientists David Seidman and Dieter Isheim to help them uncover its secrets.

To do so, the researchers needed only a single grain of the sample.

Using the LEAP 5000XS atom probe tomograph, the flagship instrument at the Northwestern University Center for Atom-Probe Tomography (NUCAPT), Seidman and Isheim visualized the lunar soil's atomic structure and determined the precise location and chemical identities of individual atoms within the grain. Normally used to study metals, semiconductors, and ceramics, the atom probe unleashed a pulsing ultraviolet laser onto the tiny lunar sample, releasing its atoms and providing data to record spatial locations in three dimensions.

"With the atom probe tomograph, we conduct chemical analyses by counting individual atoms. Our typical datasets may include tens of millions of atoms, but that's still a microscopic volume," says Seidman, Walter P. Murphy Professor of Materials Science and Engineering and director of NUCAPT. "We don't need much material to gain an understanding of the chemical composition of a sample, which is useful when the primary source, like lunar soil, is extremely finite."

In analyzing the speck of lunar dust under the atom probe, the researchers found evidence of space weathering, a phenomenon where exposure to solar and cosmic radiation induces chemical changes to the outer layer of the material. The ionized hydrogen atoms (protons) and trace amounts of helium detected, they confirmed, came from our sun. The analysis also found the presence of iron and water molecules that formed in the dust grains due to exposure to solar wind.

By pinpointing the differences between the chemical composition of lunar soil that has been exposed to space weathering and soil that has not, scientists may better understand the composition of other materials in our galaxy.

"This technology to study lunar soil wasn't available in 1972. We can answer so many more questions today with the same samples that were collected by the Apollo 17 crew," Heck says. "This work has not only reinforced the value of mission-return samples, but also how great a resource the atom probe has been for extra-terrestrial materials science research at the Field Museum and our ongoing work with Northwestern."

The lunar soil analysis is the latest collaboration between NUCAPT and the Field Museum, a partnership at the intersection of analytical materials science, planetary sciences, and cosmochemistry that dates back more than a decade. Supported by NASA, other collaborations have included analyzing presolar dust, nanodiamonds found within the Allende meteorite, and other meteoritic samples.

"Our collaborations have cascaded," says Isheim, research associate professor in materials science and engineering and NUCAPT manager. "With the technology to send probes to asteroids and comets ever improving, we're hopeful to explore even more samples in the future."

ALEX GERAGE

Photography by Sean Russell, Field Museum

ATOM PROBE TRAVELS TO THE FIELD

On display at the Field Museum's Searle Family Lounge through March 2022, the VG FIM 100 atom probe field ion microscope offers museum guests an up-close look at a device that first allowed researchers to see materials at an atomic scale.

This atom probe is the precursor to the LEAP 5000XS tomograph, the model currently used at the Northwestern University Center for Atom-Probe Tomography. Gregory Olson, a pioneer in computational materials design and Walter P. Murphy Professor Emeritus of Materials Science and Engineering, brought the device from the Massachusetts Institute of Technology after he joined the Northwestern faculty in 1988.

In 2004, Northwestern donated the VG FIM 100 atom probe to the Museum of Science and Industry. Before the atom probe arrived on loan at the Field Museum, it had been exhibited at MSI's *Materials Science* exhibit as well as at O'Hare International Airport and the Harold Washington Library Center.

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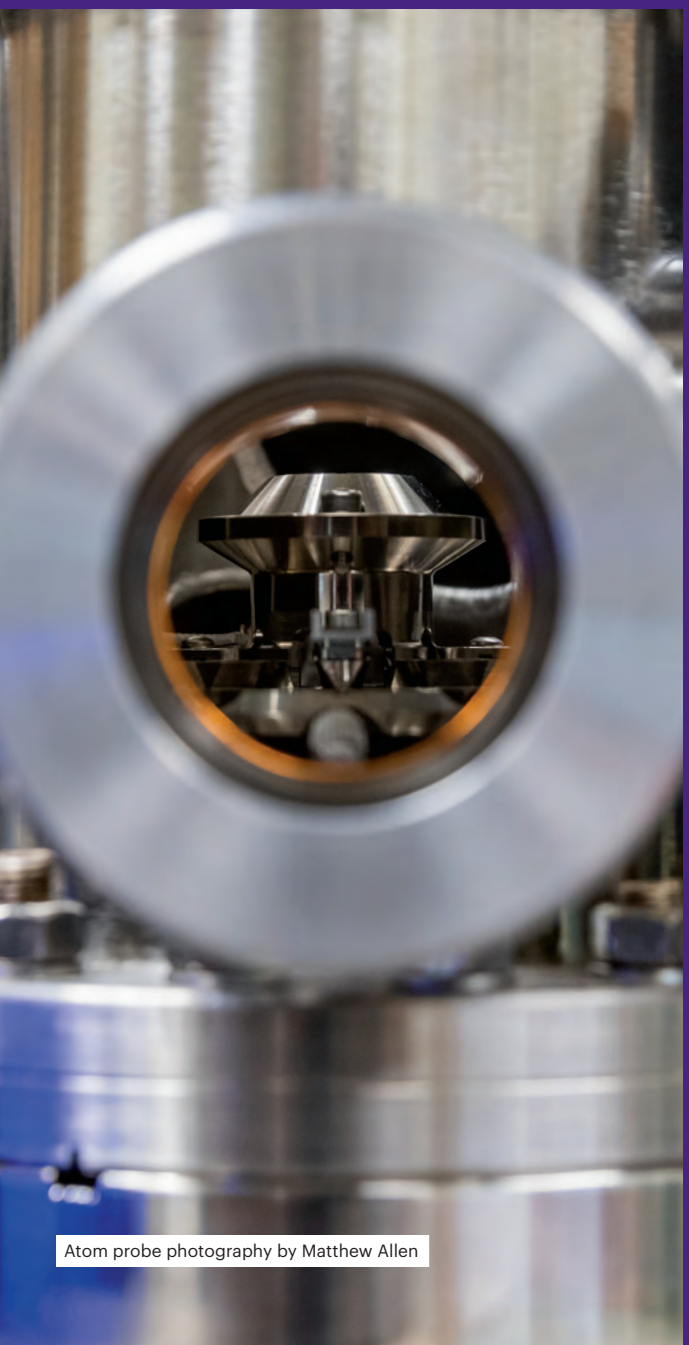
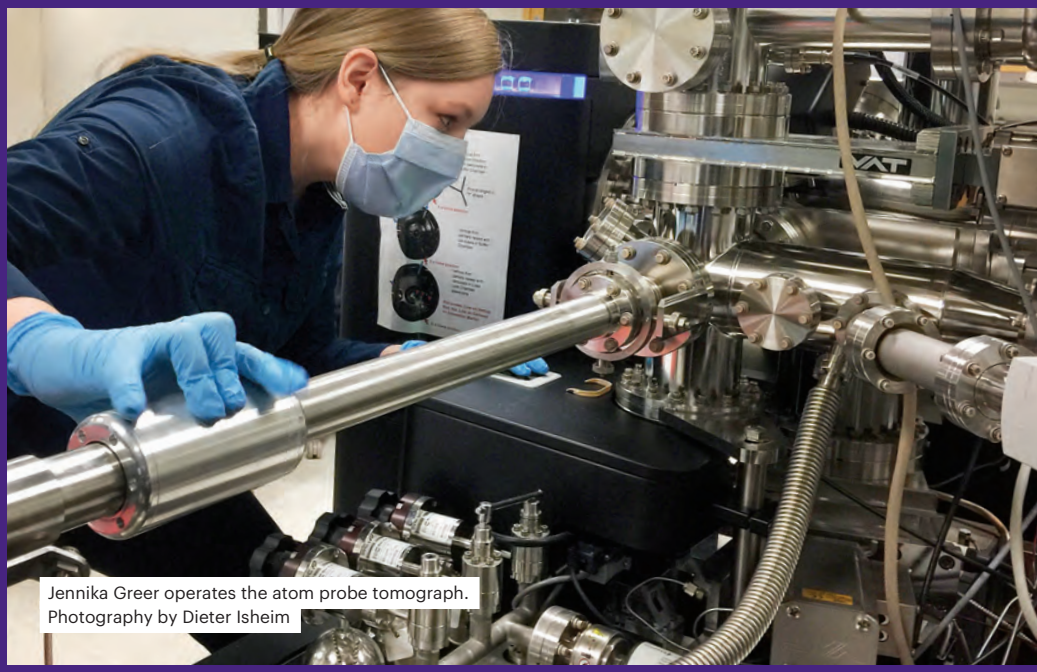
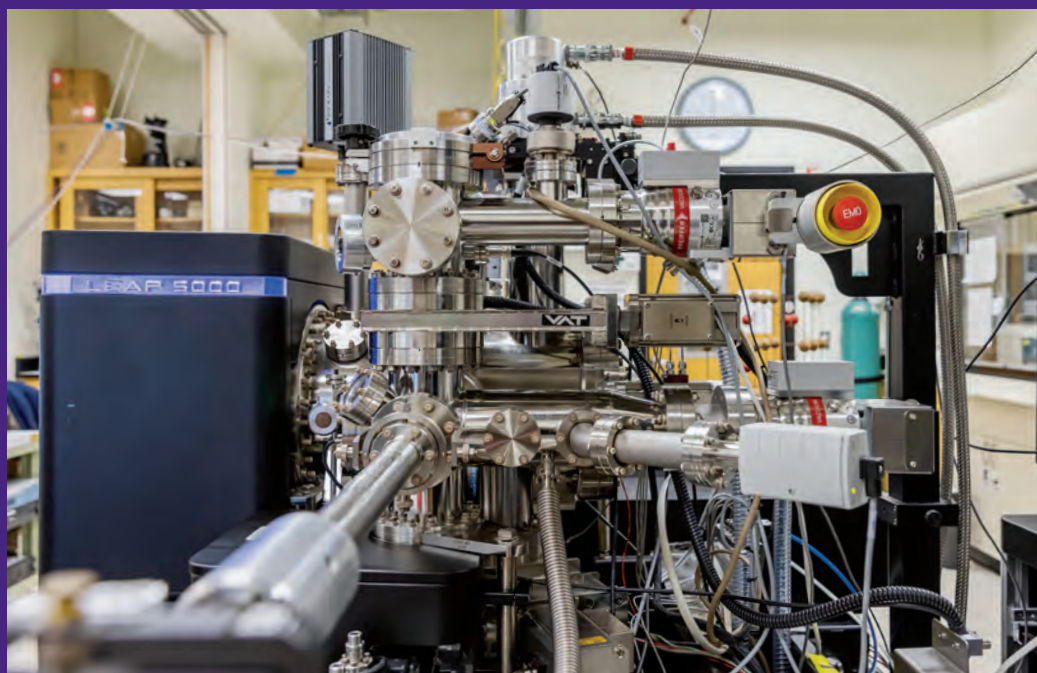
PHILIPP HECK Robert A. Pritzker Curator for Meteoritics and Polar Studies and Head of the Robert. A. Pritzker Center at the Field Museum



Atom probe photography by Matthew Allen



Jennika Greer operates the atom probe tomograph. Photography by Dieter Isheim



"OUR GOAL IN DEVELOPING FOSSIL CANYON WAS TO CREATE AN ENJOYABLE FAMILY EXPERIENCE WHILE ALLOWING CHILDREN TO ENGAGE CREATIVELY WITH PALEOBIOLOGY."

KEVIN LYNCH Professor of Mechanical Engineering and Director of the Center for Robotics and Biosystems

MAKING A GAME OF PALEOBIOLOGY

After watching his then kindergarten-age children adapt to—and at times struggle with—the challenges of remote learning brought on by the COVID-19 pandemic, the McCormick School of Engineering's Kevin Lynch and his wife, Yuko, felt inspired to help them better understand their science lessons, which included a curriculum on dinosaurs.

Working with graphic designer Nathan Martel and Akiko Shinya, chief preparator of fossil vertebrates at the Field Museum, the Lynches created Fossil Canyon, a card game where players collect dinosaur fossils to display in their own museums. The colorful cards reveal information about specific dinosaurs, including pronunciations and timeframes of when the creatures roamed the planet, and enable families to have fun and learn together. A companion booklet outlines the basics of paleontology.

"Our goal in developing Fossil Canyon was to create an enjoyable family experience while allowing children to engage creatively with paleobiology," says Kevin Lynch, professor of mechanical engineering and director of the Center for Robotics and Biosystems. "Paleobiology is not robotics, my specialty, but anything that gets kids, including my own, excited about science works for me."

As the project's science adviser, Shinya ensures the game's scientific accuracy and also interfaces with leadership at the Field Museum, a partner in the project. "Kevin's passion for education was inspiring and I was impressed with his creativity and dedication," Shinya says. "Fossil Canyon is packed with science and much more educational than a simple card game. I was thrilled that I could advise on its scientific contents."

Polymath Play, the parent company for Fossil Canyon, successfully funded the production of 2,000 copies of the game with a Kickstarter campaign in the summer of 2021. Fossil Canyon might eventually be sold in Field Museum gift shops.

"The Field Museum excels in scientific research and outreach to the public. It was exciting to have an opportunity to work with them, and Akiko specifically, on this unique science outreach project," Kevin Lynch says. "They are pros at science communication, and science communication is an important part of what we do. It's been both fun and educational."

ALEX GERAGE AND BRIAN SANDALOW

COLLABORATIONS SPAN DISCIPLINES

Combining unique domain expertise with innovative research technology and methodologies, scientists from Northwestern Engineering and the Field Museum have shown that collaboration happens best at the intersection of disciplines. Other collaborations between the two have included:

Understanding Coral Bleaching

Warmer ocean waters caused by climate change have jeopardized the long-term health of coral reefs. Luisa Marcelino, research assistant professor of civil and environmental engineering and a scientific affiliate at the Field Museum, along with Vadim Backman, Sachs Family Professor of Biomedical Engineering and Medicine, worked with Field Museum biologists to study why some species of coral are more susceptible than others to coral bleaching, a phenomenon that occurs when changes in environmental conditions cause coral to expel their life-giving algae. Using Backman's optical imaging technology originally designed for early cancer detection, the researchers discovered that corals that are less efficient at scattering light to nearby symbiotic algae—a food source for the corals—are more likely to survive when stressed.

Optimizing Digital Displays for Natural History Exhibits

How can museums give visitors a greater appreciation of artifacts they can't touch or manipulate? That's the question Michael Horn, associate professor of computer science and of education and social policy at Northwestern, and Matt Matcuk, exhibitions development director at the Field Museum, set out to answer. Using cognitive curiosity models, the two tested three designs of an interactive sign display within the museum's Cyrus Tang Hall of China exhibit. Measuring visitor curiosity, interest, and engagement with the signage, they found that presenting bold questions on interactive display screens can help draw visitors in, while more visually engaging displays help promote user interaction.