

Wondrous Science

A kaleidoscope of colors vivid and vibrant, shapes and texture using a palette that only Mother Nature could provide. The imagery shown here was captured by researchers at the Pacific Northwest National Laboratory on their quest to advance scientific frontiers and solve complex problems. They apply their knowledge to address our nation's most intractable problems in energy, the environment and national security.

From breakthroughs in fundamental and computational sciences that help our understanding of the world around us—to exploring the possibility of storing carbon emissions in basalt rock—to creating composites that mimic rare actinide materials—at PNNL we have dedicated our life's work to wondrous science.



Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by **Battelle** Since 1965

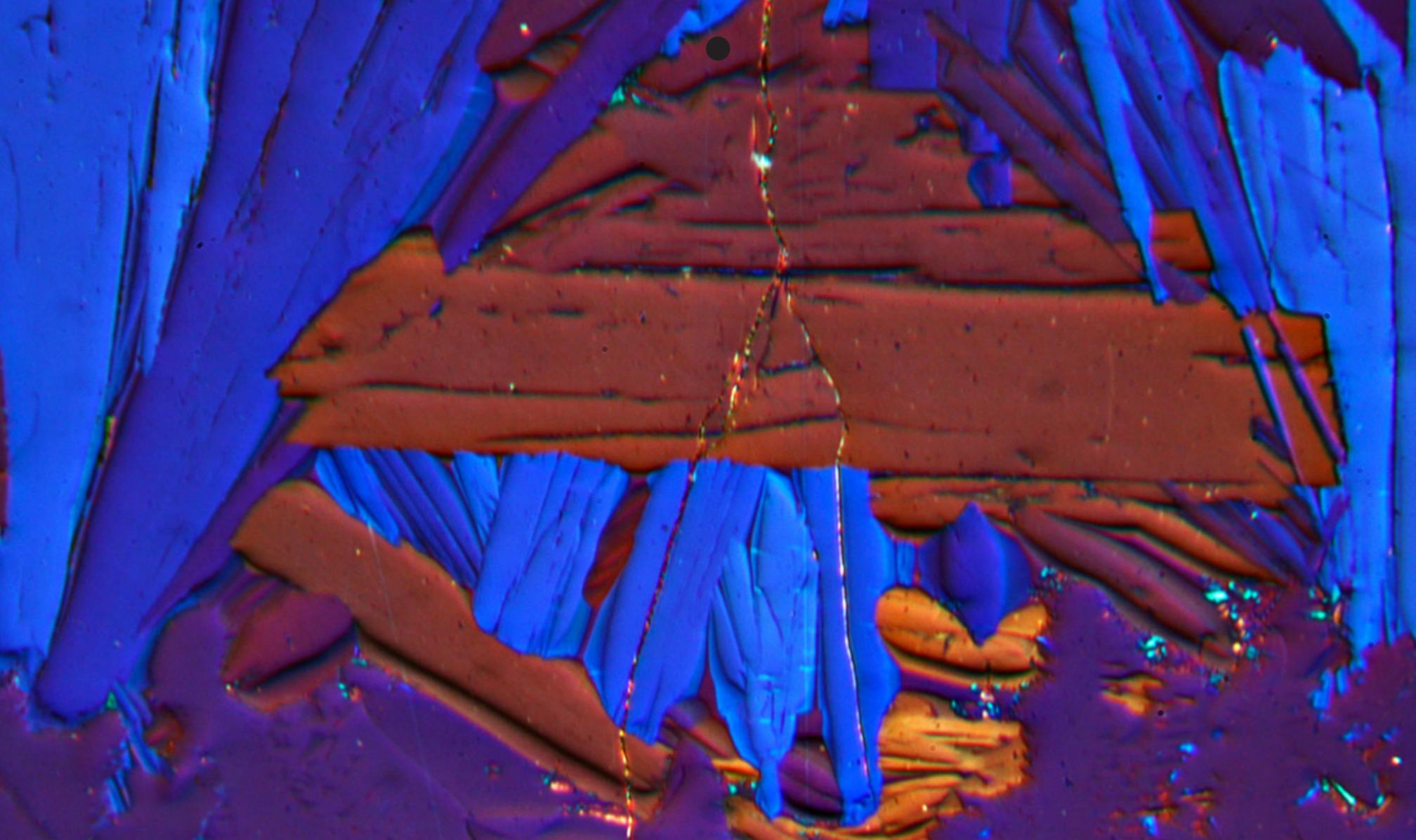


One potential method for reducing greenhouse gas emissions is to capture and store them in deep, underground reservoirs. PNNL scientists discovered new chemical reactions between basalt and other types of reservoir rocks with supercritical carbon dioxide containing small amounts of water. These reactions quickly turn the carbon dioxide into carbonate minerals, reducing the risks of accidental escape. This discovery provides engineers new options for managing the underground chemistry and permanently trapping emissions. This image of calcium carbonate crystals formed on a basalt rock sample was provided by PNNL scientist Pete McGrail.

JANUARY 2011



| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---|--|---------|-----------|----------|--------|---|
| DECEMBER 2010 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | FEBRUARY 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 | | | | | 1 <i>New Year's Day Kwanzaa Ends</i> |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 16 | 17 <i>Martin Luther King Jr.'s Birthday</i> | 18 | 19 | 20 | 21 | 22 |
| 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| 30 | 31 | | | | | |

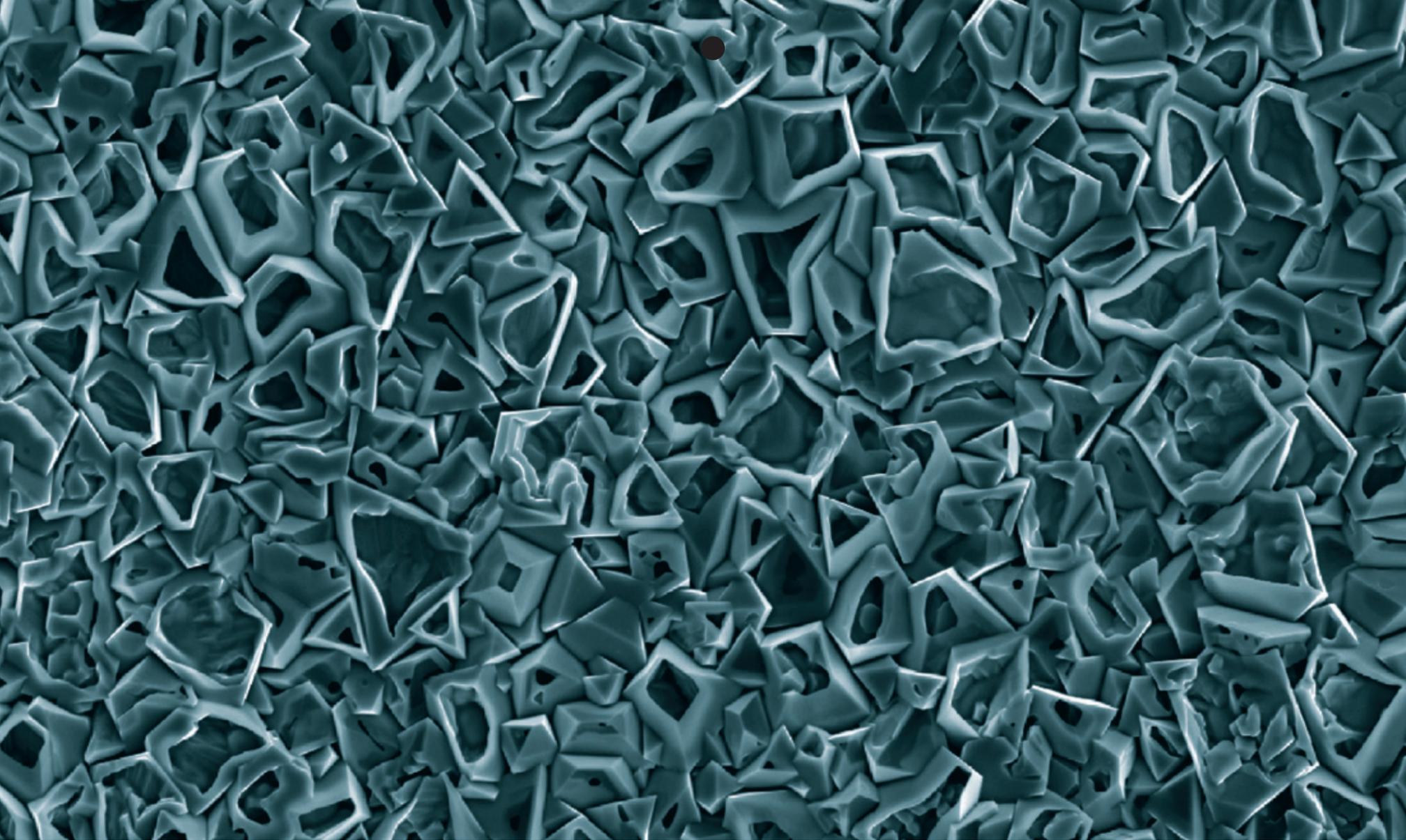


Using polarized reflective light, PNNL scientists discovered a novel new compound— $Cd_3Ge_2As_4$. This breakthrough was made while conducting experimental work to develop new semiconductors. The new material potentially has applications in infrared optics and electronics. The specimen was imaged in cross-polarized reflected light. The different colors are due to birefringence in the crystal caused by light traveling at different speeds along different crystallographic axes. The image was captured by scientist Brad Johnson. The team of researchers on this project includes Brian Riley, Joe Ryan, John McCloy, Jarrod Crum, and SK Sundaram.

FEBRUARY 2011


Pacific Northwest
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| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------|------------------------------|------------------------------------|---------------------------|---|---|--|
| | | 1 | 2 <i>Groundhog Day</i> | 3 ● <i>Chinese Lunar New Year</i> | 4 | 5 |
| 6 | 7 | 8 | 9 | 10 ◐ | 11 | 12 <i>Lincoln's Birthday</i> |
| 13 | 14 <i>Valentine's Day</i> | 15 | 16 | 17 | 18 ○ | 19 |
| 20 | 21 <i>President's Day</i> | 22 <i>Washington's Birthday</i> | 23 | 24 | 25 ◑ | 26 |
| 27 | 28 | | | | JANUARY 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | MARCH 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 |

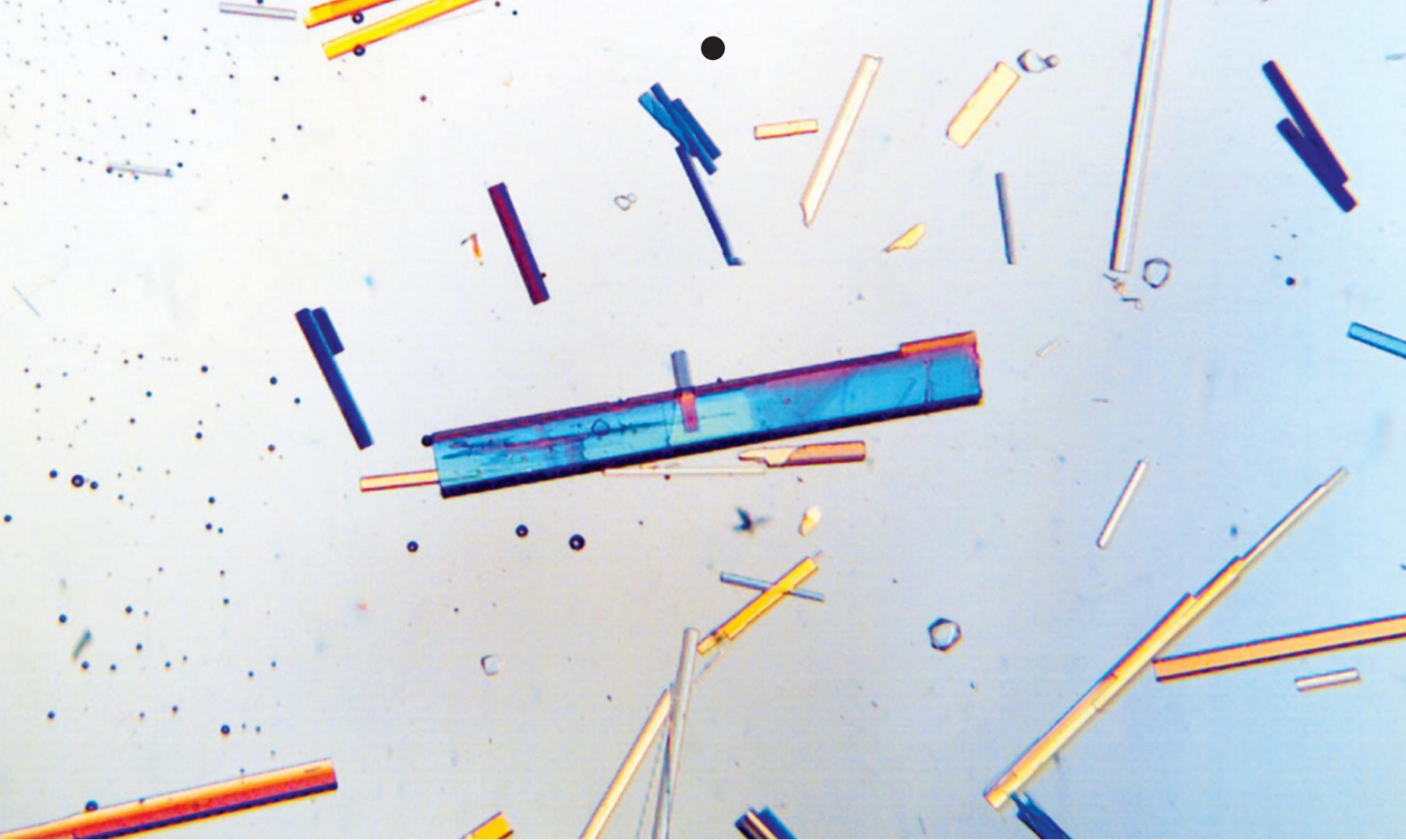


PNNL scientists research materials that mimic the chemical and physical aspects of debris from nuclear explosions in the environment and discover signatures that can be used to prevent proliferation of nuclear weapons. Shown here is a sheet of copper exposed to a plasma flame (~8300 degrees Celsius) for several seconds. The image was taken by scientists Alison Eckberg and Ben Garcia of material created by researcher Martin Liezers; Greg Eiden is project principal investigator.

MARCH 2011



| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---|--------|------------------------|-----------|--------------------------------|--|---|
| | | 1 | 2 | 3 | 4 | 5 |
| 6 | 7 | 8 <i>Mardi Gras</i> | 9 | 10 | 11 | 12 |
| 13 <i>Daylight Savings Time Begins</i> | 14 | 15 | 16 | 17 <i>St. Patrick's Day</i> | 18 | 19 |
| 20 <i>First Day of Spring</i> | 21 | 22 | 23 | 24 | 25 | 26 |
| 27 | 28 | 29 | 30 | 31 | FEBRUARY 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 | APRIL 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 |

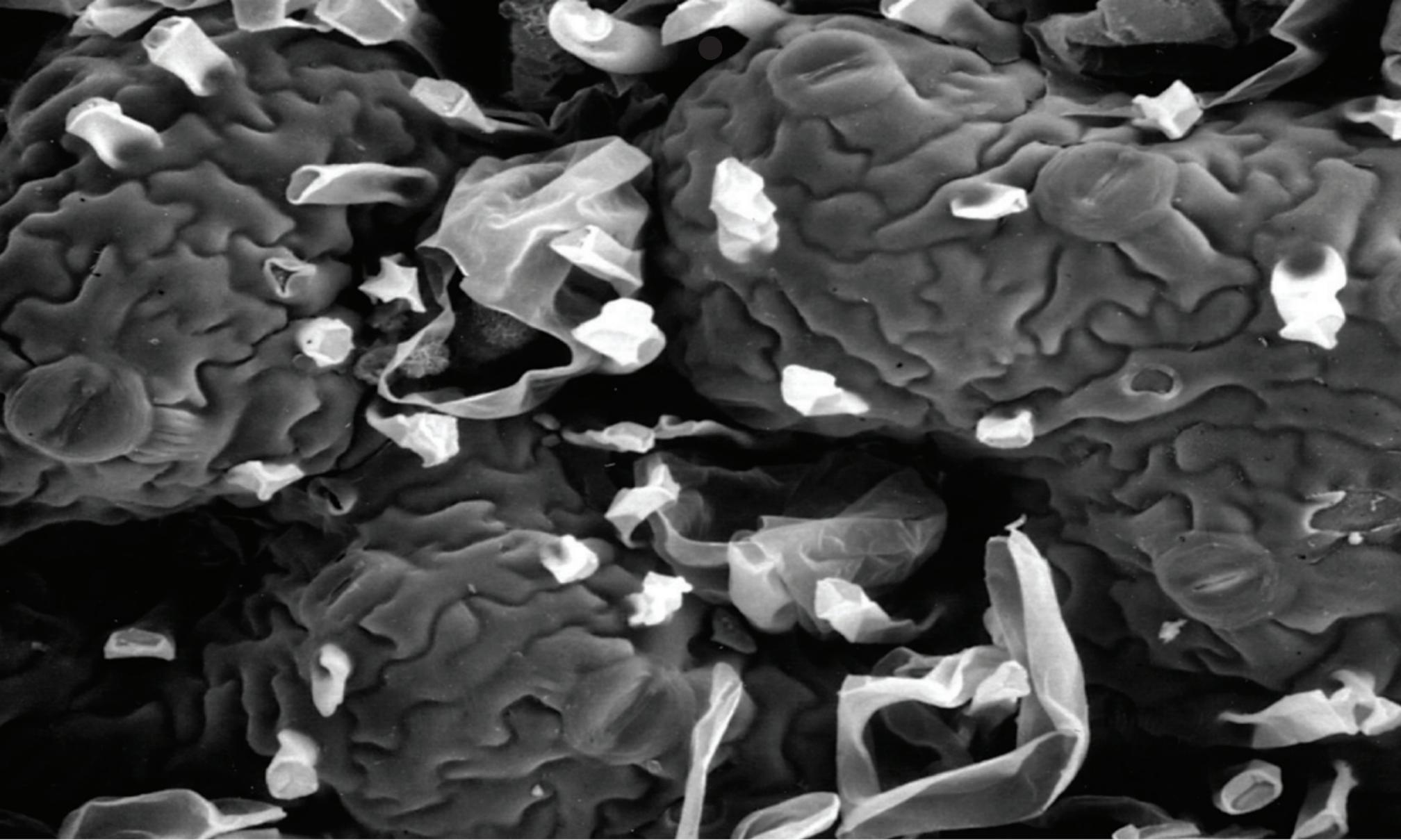


One of the challenges of using nuclear energy is ensuring safe treatment of waste. PNNL scientists and engineers simulate nuclear waste in a laboratory setting to study processing issues with large-scale vitrification. Captured here, by scientists Brian Riley and Jarrod Crum, is an optical micrograph of sodium oxalate crystals taken under cross-polarized light. These crystals are an unwanted precipitate identified by our scientists in the process supernatant.

MAY 2011



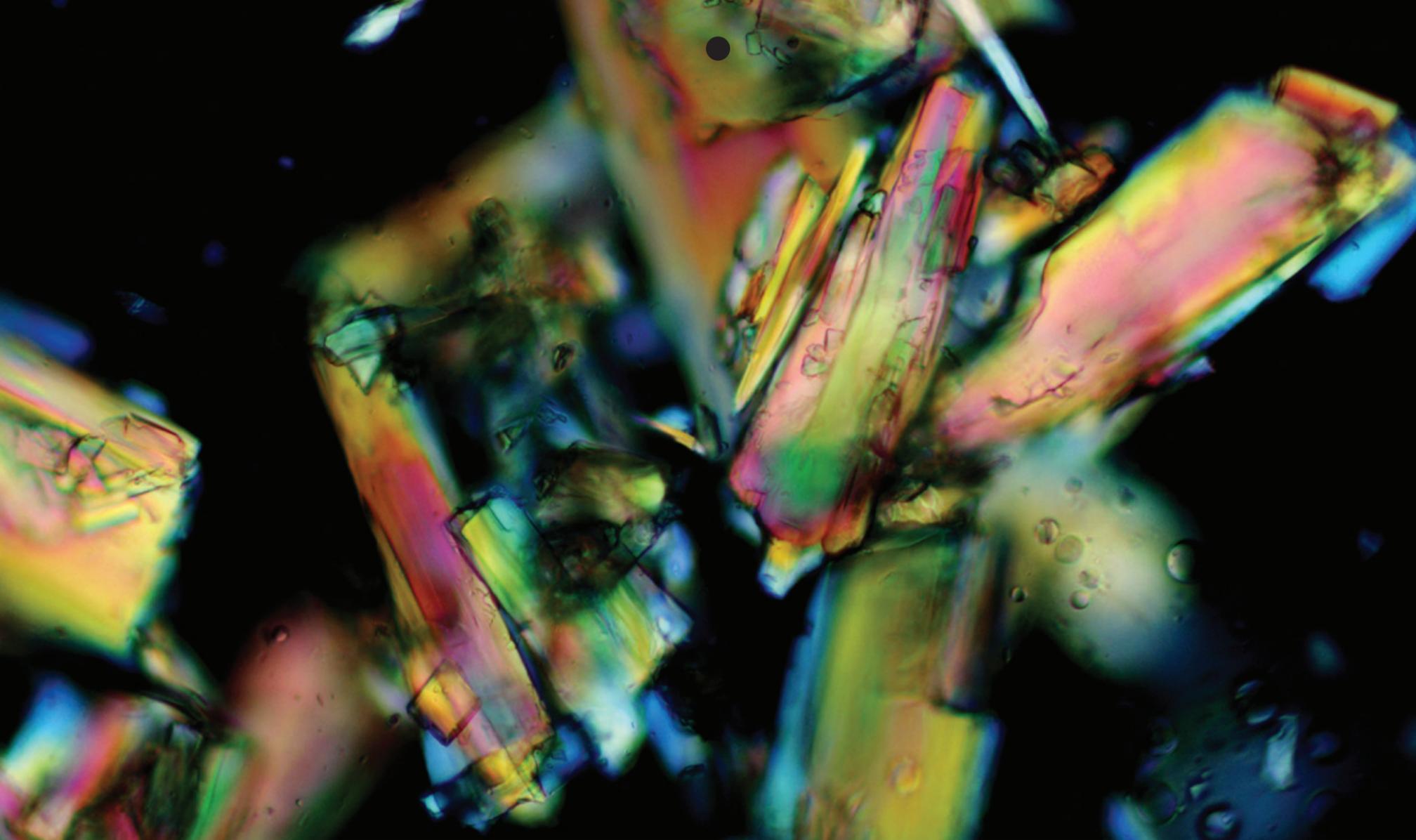
| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--------------------------|---------------------------|---------|-----------|---------------------------|---|--|
| 1 | 2 | 3 | 4 | 5 <i>Cinco De Mayo</i> | 6 | 7 |
| 8 <i>Mother's Day</i> | 9 | 10 | 11 | 12 | 13 | 14 |
| 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 29 | 30 <i>Memorial Day</i> | 31 | | | APRIL 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 | JUNE 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 |



After removing the leaf hairs on big sagebrush leaves, scientists at PNNL used scanning electron microscopy to develop images showing the position and number of stomata and guard cells on the leaf surface. The number and size of stoma found on leaf surfaces of desert shrubs varies and controls the rate of water loss from plants. Understanding plant transpiration water loss is important to estimate plant water use and predict total water balance in contaminated environments. This image was taken by scientist Janelle Downs through a project in collaboration with Washington State University.

JUNE 2011

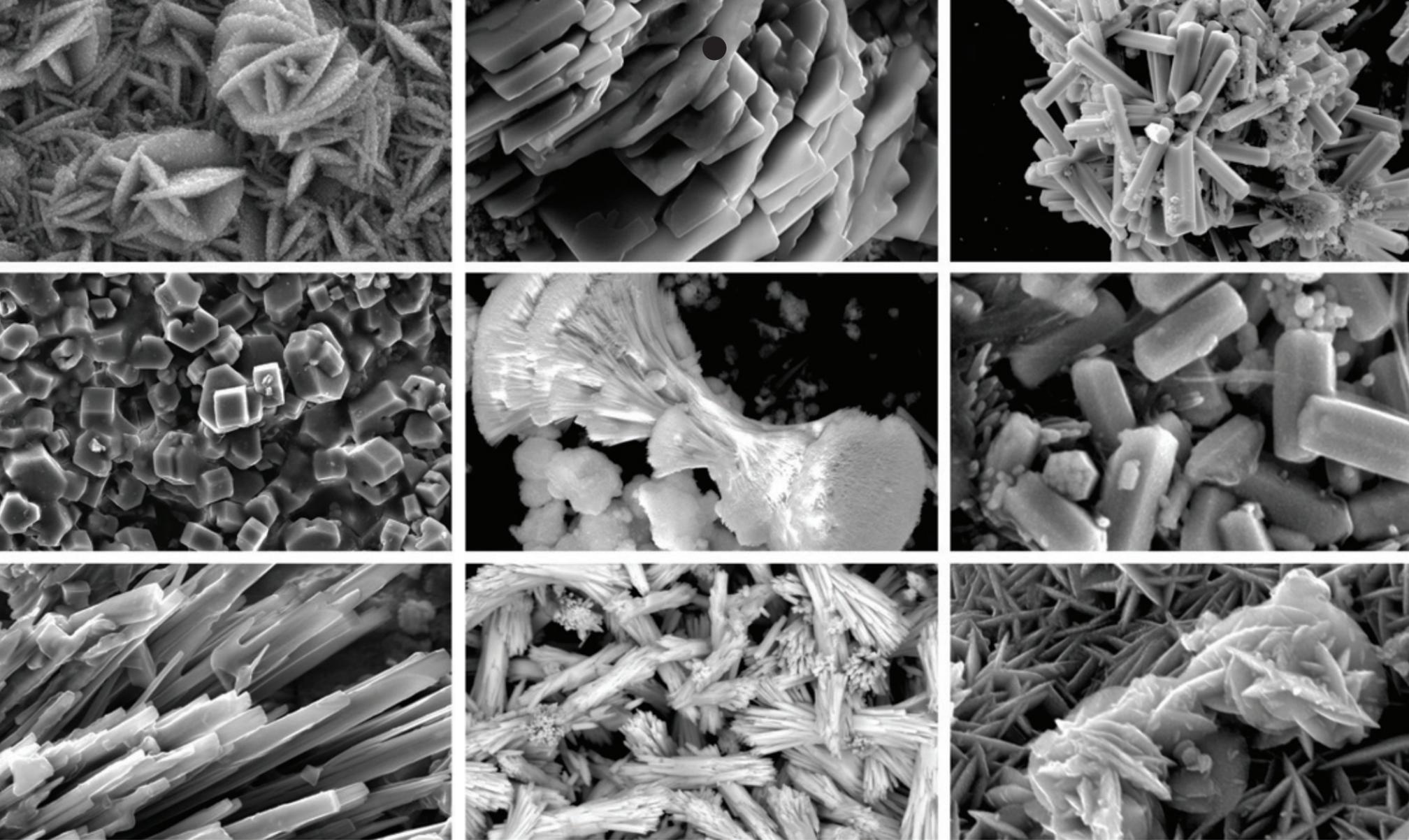
| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---------------------------|--------|----------------------------------|-----------|----------|--|--|
| | | | ● 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | ◐ 8 | 9 | 10 | 11 |
| 12 | 13 | 14 <i>Flag Day</i> | 15 | ○ 16 | 17 | 18 |
| 19 <i>Father's Day</i> | 20 | 21 <i>First Day of Summer</i> | 22 | ◑ 23 | 24 | 25 |
| 26 | 27 | 28 | 29 ● | 30 ● | MAY 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | JULY 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 |



Using expertise in material nuclear forensics, PNNL scientists and engineers are developing cutting-edge signature discovery tools related to the nuclear fuel cycle. This image of thorium nitrate and uranyl sulfate crystals was obtained from a Nikon 400 POL polarized light microscope (PLM) with cross-polars. The PLM provides unique insight into materials and enables rapid screening of unknowns. The cross-polars image of uranyl sulfate shows large 0.5-millimeter crystals exhibiting a wealth of interference colors. Contrast in the images are due to thickness variations across the crystal, much like the interference colors from an oil slick on water. PNNL scientists Leah Arrigo and Crystal Rutherford contribute to the project, which is managed by Jon Schwantes. This image was provided by PNNL scientist Edgar Buck.

JULY 2011

| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|--|---|---------|-----------|----------|--------|----------|
| JUNE 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 | AUGUST 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | | | | 1 | 2 |
| 3 | 4 <i>Independence Day</i> | 5 | 6 | 7 | 8 | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| 23 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 <i>Ramadan Begins at Sunset</i> | | | | | | |

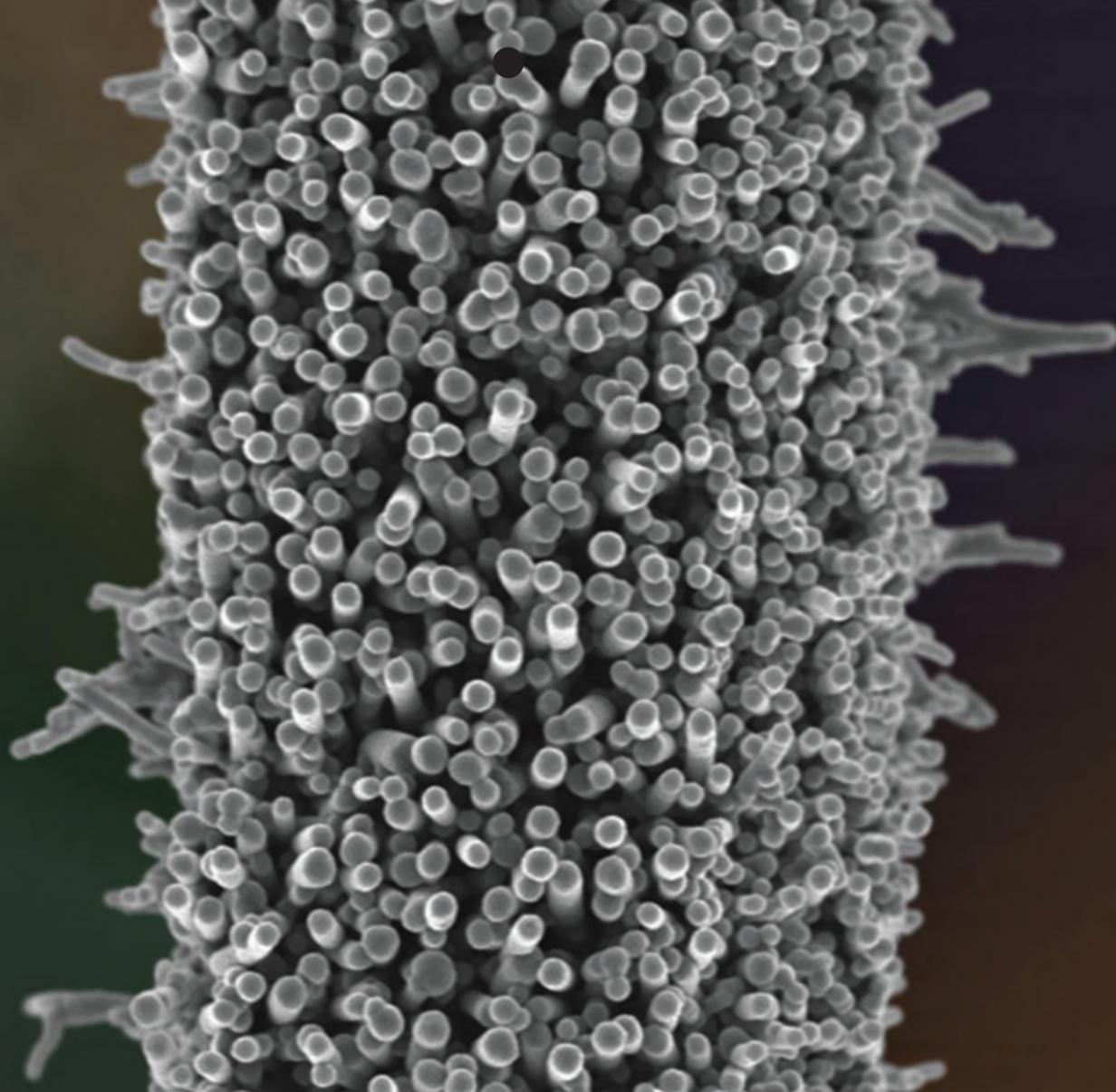


PNNL scientists created a collage of rare earth micro-composites—yttrium phosphate and lanthanoid phosphate composites of micrometer dimensions generated by hydrothermal synthesis. These composites serve as surrogates for rare earth and actinide materials. Exploring these materials will provide insight into the soil structure and spectroscopic behavior of complex actinide materials, and help design new technologies to clean up contaminated soils and groundwater. PNNL researchers Dev Chatterjee, Matt Edwards, Sam Bryan and intern Tim Billman worked on the project. These images were captured by researcher Paul MacFarlan.

AUGUST 2011



| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
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| 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| 28 | 29 <i>Ramadan Ends</i> | 30 | 31 | | JULY 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | SEPTEMBER 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 |

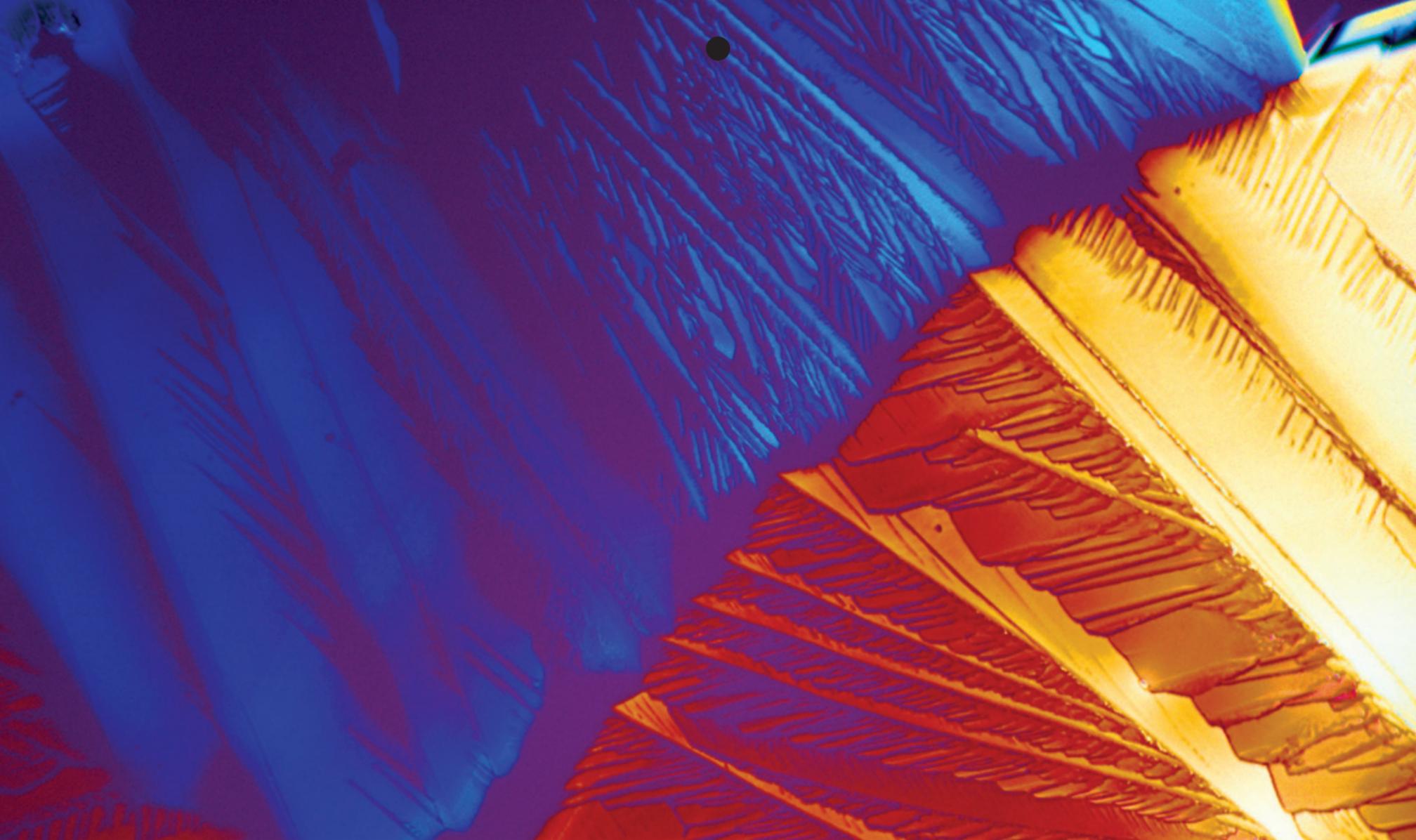


PNNL scientists study polypyrrole conductive polymer-coated carbon nanotubes grown on a carbon fiber at EMSL, a DOE national scientific user facility located at PNNL. These nanotubes could be used as an electrochemically switched ion exchange electrode for water purification. This work is part of efforts to obtain a high-surface-area electrode for efficient water purification. PNNL operates EMSL, the Environmental Molecular Sciences Laboratory, for DOE. Image captured by Daiwon Choi, Bruce Arey and Yuehe Lin.

SEPTEMBER 2011



| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
|---|---|--|---|----------|--------------------------------------|----------|
| AUGUST 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | OCTOBER 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | | | 1 | 2 | 3 |
| 4 |  5 <i>Labor Day</i> | 6 | 7 | 8 | 9 | 10 |
| 11 <i>Patriot Day</i> | 12 |  13 | 14 | 15 | 16 | 17 |
| 18 | 19 |  20 | 21 | 22 | 23 <i>First Day of Autumn</i> | 24 |
| 25 | 26 |  27 | 28 <i>Rosh Hashanah Begins at Sunset</i>  | 29 | 30 | |



PNNL scientists and engineers are leading cutting-edge nuclear fuel cycle research. Recent striking examples of this research are illustrated in these microscope images of thorium nitrate crystals. During the crystallization of thorium nitrate in methanol, solidified regions have grown radially. These crystals were observed with cross-polarized illumination. PNNL scientists Leah Arrigo and Crystal Rutherford contribute to the project, which is managed by Jon Schwantes. This image was provided by PNNL scientist Edgar Buck.

OCTOBER 2011

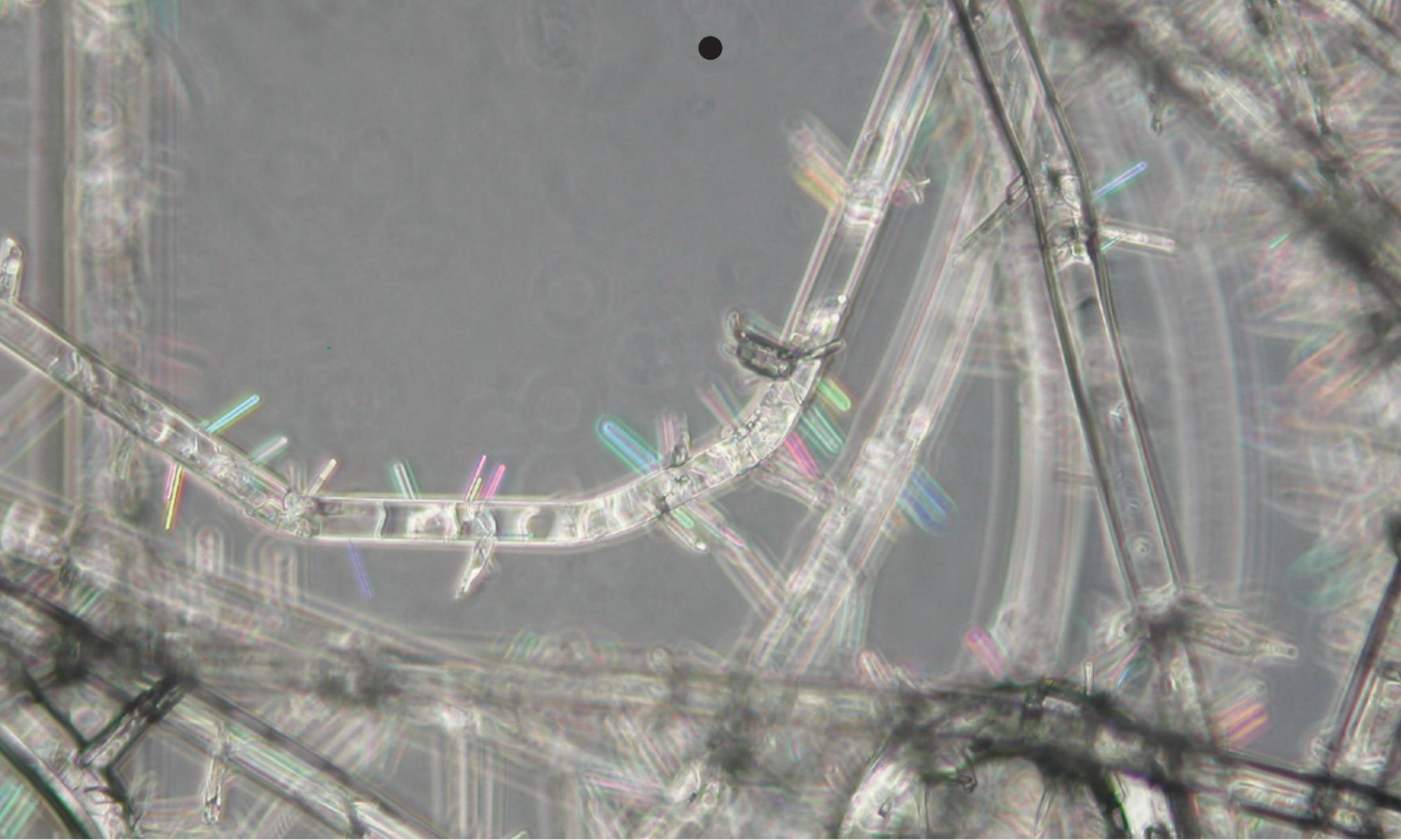


| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
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| SEPTEMBER 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 | NOVEMBER 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 | | | | | 1 |
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| 30 | 31 | | | | | |

Yom Kippur Begins at Sunset

Columbus Day

31 Halloween



Scientists and engineers at PNNL are developing fuel cell power systems for a variety of applications ranging from small portable power systems for national security applications to large stationary power plants. Combining ammonia and borane creates a safe and solid molecular crystal that can be used to store hydrogen for fuel cell power applications. The image here, submitted by scientists Tom Autrey and David Heldebrant, shows light diffraction through crystals of ammonia borane.

DECEMBER 2011



| SUNDAY | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY | SATURDAY |
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| NOVEMBER 2011 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 | JANUARY 2012 S M T W T F S 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 | | | 1 | 2 | 3 |
| 4 | 5 | 6 | 7 <i>Pearl Harbor Remembrance Day</i> | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| 18 | 19 | 20 <i>Hanukkah Begins at Sunset</i> | 21 | 22 <i>First Day of Winter</i> | 23 | 24 <i>Christmas Eve</i> |
| 25 <i>Christmas</i> | 26 <i>First Day of Kwanzaa</i> | 27 | 28 <i>Hanukkah Ends</i> | 29 | 30 | 31 <i>New Year's Eve</i> |

2012 CALENDAR

JANUARY 2012

| S | M | T | W | T | F | S |
|----|----|----|----|----|----|----|
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FEBRUARY 2012

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MARCH 2012

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APRIL 2012

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MAY 2012

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JUNE 2012

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JULY 2012

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AUGUST 2012

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SEPTEMBER 2012

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OCTOBER 2012

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NOVEMBER 2012

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DECEMBER 2012

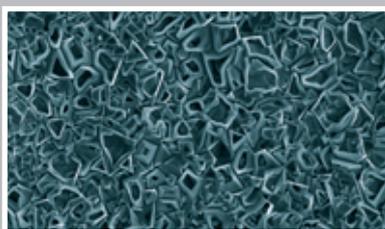
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| 30 | 31 | | | | | |



JANUARY



FEBRUARY



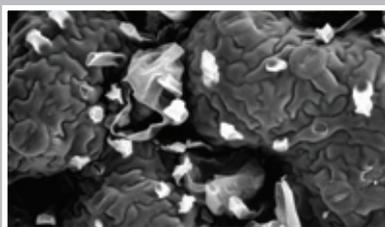
MARCH



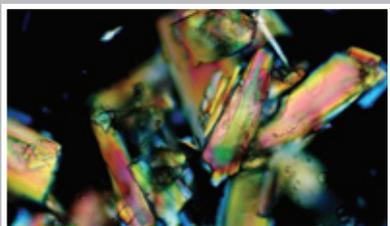
APRIL



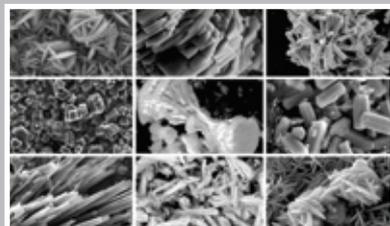
MAY



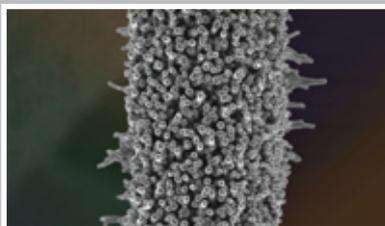
JUNE



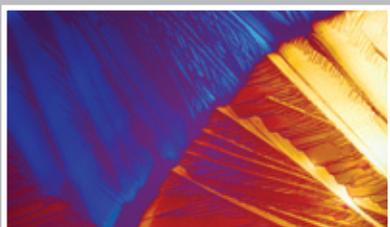
JULY



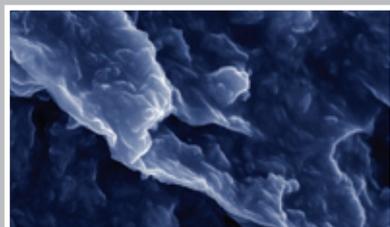
AUGUST



SEPTEMBER



OCTOBER



NOVEMBER



DECEMBER

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