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DISCOVERY *in Action*

2013 CALENDAR

Identifying and Protecting Alaskan Fishery Habitats

This aerial photo shows open water and floating ice on ponds, lakes and river channels in the Sagavanirktok River Delta in Alaska's North Slope. PNNL scientists employed satellite technology to characterize the impacts of oil development activities on the environment. Using satellite radar to "see" through the ice, scientists detected critical fish overwintering habitats by identifying where ice was grounded and where it was floating. Utilizing this information on critical habitats, fishery managers can suggest locations for energy development activities that increase the sustainability of fishery resources and minimize the environmental impact. Research was funded by the U.S. Department of the Interior.

Team Members from PNNL: Richard Brown, Robert Mueller and Jerry Tagestad.

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SEPTEMBER 2013

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OCTOBER 2013

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DECEMBER 2013

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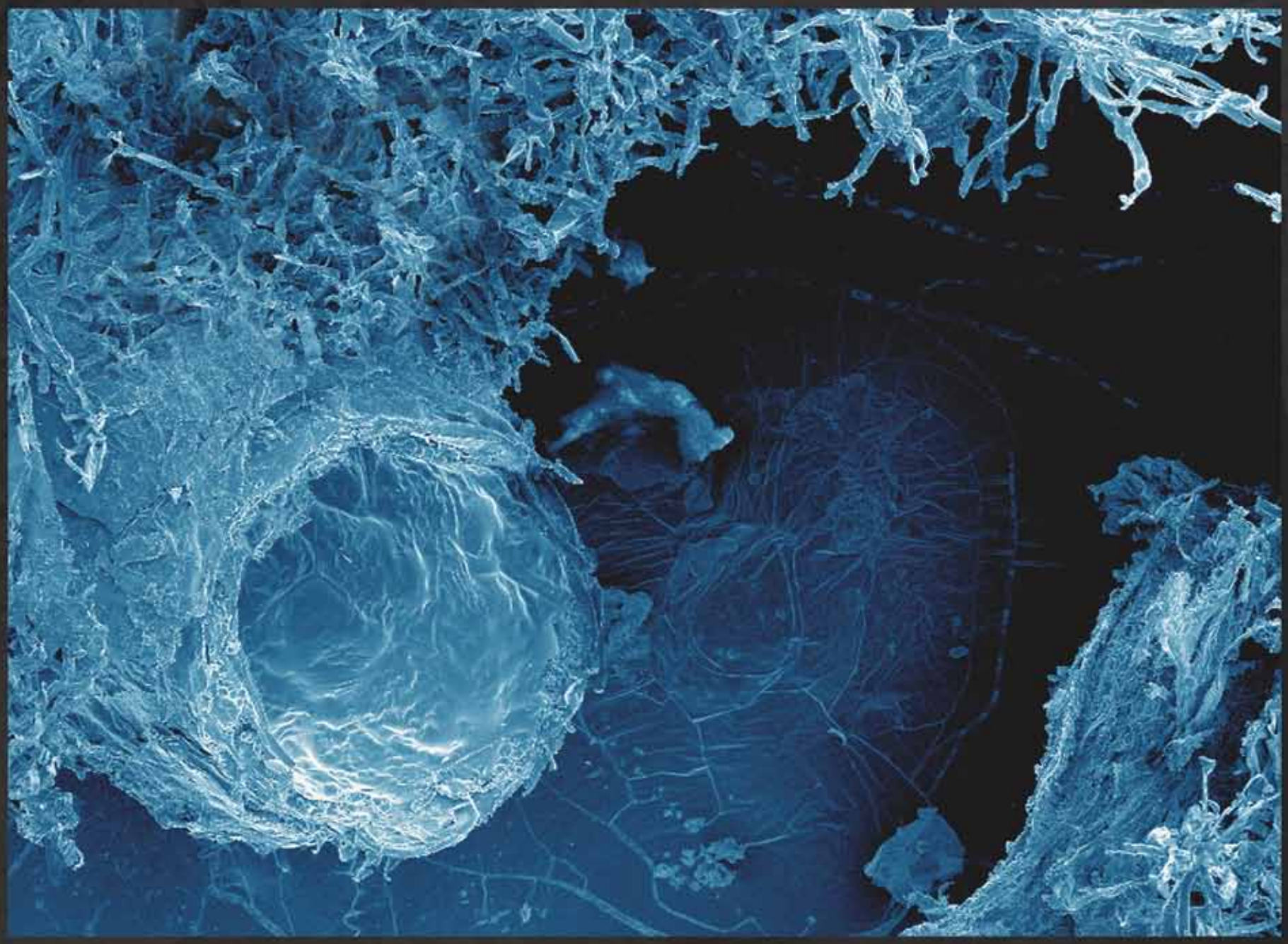
All times shown are in Universal Time (UT) which approximates Greenwich Mean Time (GMT). Therefore the reader should adjust the Universal Time to his or her time zone, which may change the calendar dates of certain lunar events. Moon phase times shown are approximate. Change of seasons is based on Universal Time. Those holidays which are by regional proclamation may change from the date shown.

EARTH-FRIENDLY
BrownTrout products are printed on Forestry Stewardship Council (FSC) certified paper from managed forests and are printed with soy and vegetable-based inks, which are less harmful to the environment than petroleum-based alternatives.

Photography, captions and design courtesy of the Pacific Northwest National Laboratory (PNNL), proudly operated by Battelle since 1965 for the U.S. Department of Energy.



A New Look at the Root of the Problem

This is a colorized scanning electron microscopy image of a pine tree root surrounded by a soil fungus. The rhizosphere represents a critical zone where plant roots, microbes and minerals interface, and where biogeochemical weathering provides nutrients to plants. The mechanistic, sub-micron-scaled exploration will contribute to a better understanding of Earth's biogeochemical cycles, in order to determine humanity's influence on global elemental cycles and ensuring sustainable and adaptive agro-ecosystems in response to climate change. The image is one result of a collaborative effort involving PNNL and Washington State University. Research was funded by the National Science Foundation and the U.S. Department of Energy.

Team Members: Alice Dohnalkova from PNNL; Kent Keller, Zhenquing Shi, Linda Thomashow and James Harsh from WSU; and Zsuzsanna Balogh-Brunstad from Hartwick College, NY.

**Image was captured using instrumentation at EMSL, a DOE national user facility at PNNL.*

January 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
30	31	1	2	3	4	5 Last Quarter 3:58 U.T.
6	7	8 New Year's Day Kwanzaa ends	9	10	11	12 New Moon 19:44 U.T.
13 Epiphany	14	15	16	17	18	19 First Quarter 23:45 U.T.
20	21	22	23	24	25	26
27 Full Moon 4:38 U.T. Holocaust Memorial Day (UN)	28 Martin Luther King, Jr. Day (US)	29	30	31		

DECEMBER 2012

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FEBRUARY 2013

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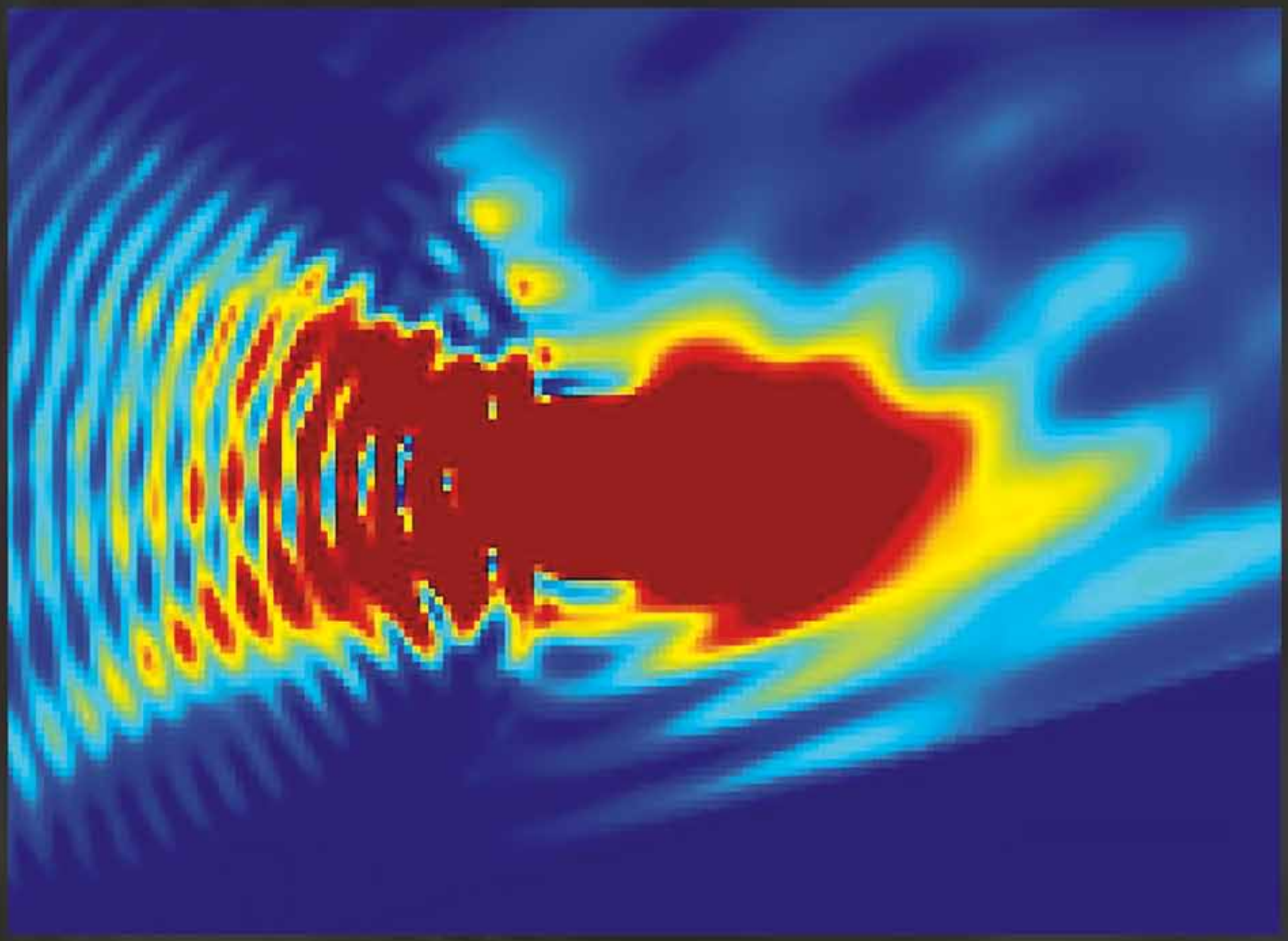

Extreme Light Focusing

Scientists studying the inner workings of toxin-eating microbes, cancer cell propagation and other processes involving tiny samples need powerful microscopes that can focus on objects nearly 1,000 times smaller than the period at the end of this sentence. One challenge to creating such a microscope is the need to focus light at this scale. Using computer models of light and a transparent sphere hundreds of times smaller than one grain of table salt, researchers at PNNL showed they can focus light to an incredibly small and intense spotlight. This ability will enable researchers to visualize structure on extremely small length scales using visible light. A microscope that incorporates this light-focusing property would revolutionize the field with spatial resolution comparable to expensive and bulky scanning electron or transmission electron microscopes.

Team Members from PNNL: Samuel Peppernick, Alan Joly, Kenneth Beck and Wayne Hess.

February 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
27	28	29	30	31	1	2 Groundhog Day
3 Last Quarter 13:56 U.T.	4	5	6	7	8	9
10 New Moon 7:20 U.T.	11	12	13	14	15	16
17 Chinese New Year (Snake) First Quarter 20:31 U.T.	18 Presidents' Day (US) Family Day (AB, ON, SK-CAN) Louis Riel Day (MB-CAN)	19 Shrove Tuesday Fat Tuesday Mardi Gras Lincoln's Birthday (US)	20 Ash Wednesday	21	22 Valentine's Day Washington's Birthday (US)	23
24	25 Full Moon 20:26 U.T.	26	27	28		

JANUARY 2013

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MARCH 2013

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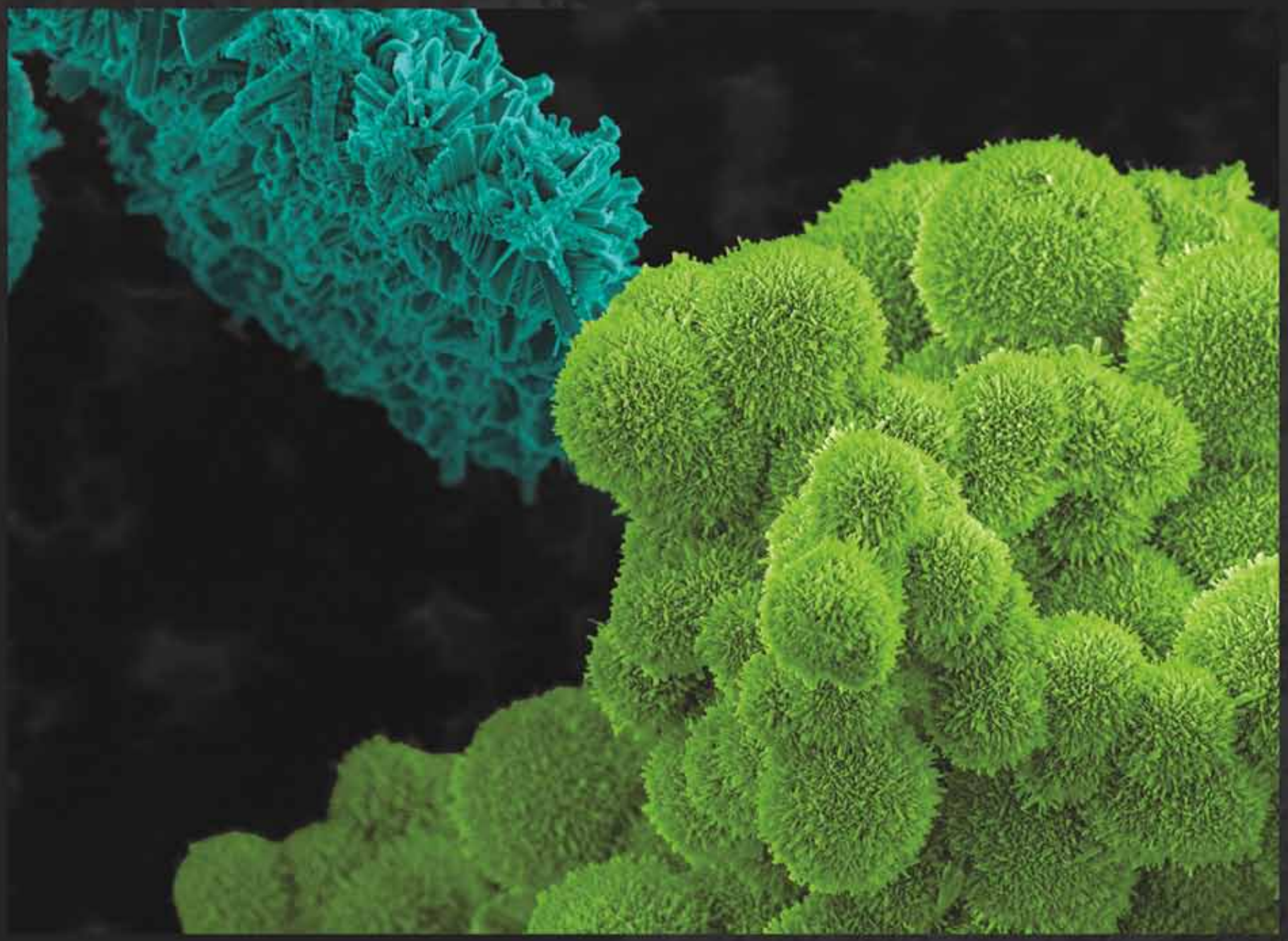


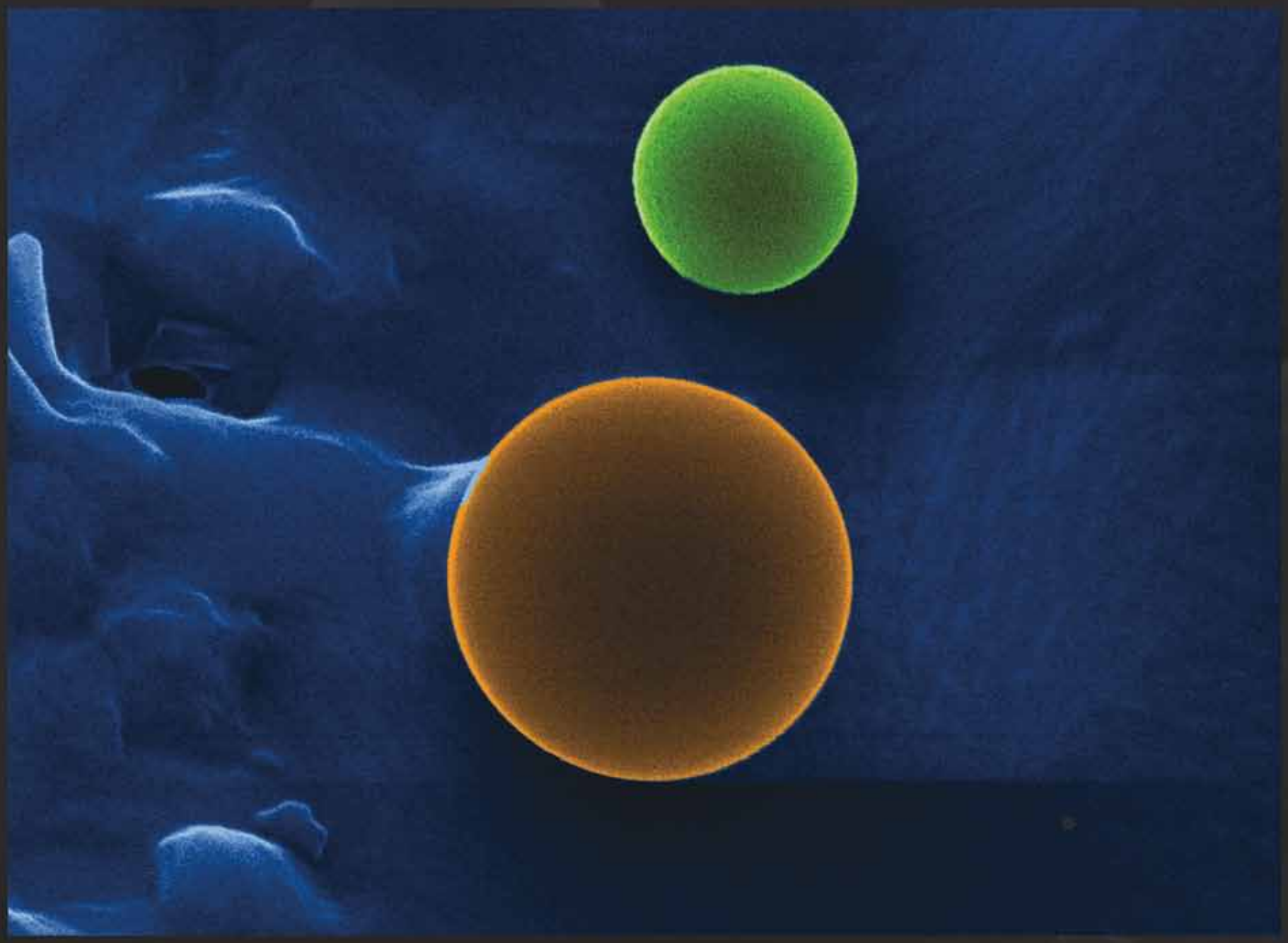
Understanding Chemicals to Help Treat Radioactive Wastes

Concentrated wastes generated during the nation's production of plutonium are stored in underground tanks at the Hanford Site in southeastern Washington state. These wastes naturally create unusual minerals such as cancrinite, as shown in this image. Cancrinite is formed when dissolved sodium aluminate, silicate, carbonate and nitrate precipitate as a solid from the liquid waste. The cancrinite that forms in the waste tanks is unique in that it captures nitrate ions—ions that are normally soluble in water and, under the right circumstances, could escape from the waste and move into the groundwater. Cancrinite and other minerals are of interest as solid waste forms that may effectively isolate mobile radioactive elements from the environment for thousands of years. Research was funded by the U.S. Department of Energy.

Team Members from PNNL: Paul MacFarlan, Edgar Buck, Bruce McNamara and Cal Delegard.

March 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
FEBRUARY 2013 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 2013** 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	26	27	28	1	2
3	4 Last Quarter 21:53 U.T.	5	6	7	8	9
10 Daylight Saving Time begins	11 New Moon 19:51 U.T. Commonwealth Day	12	13	14	15 International Women's Day	16
17	18	19	20 First Quarter 17:27 U.T.	21 Spring begins	22	23
24 St. Patrick's Day Palm Sunday	25 Great Lent begins (Orthodox)	26	27	28 Full Moon 9:27 U.T.	29	30
31 Easter Sunday	Passover begins at sundown			Maundy Thursday	Good Friday	Holy Saturday



Understanding the Origin of the Universe

Great discoveries often need great tools. Powerful scientific accelerators, lasers and electron microscopes rely on photocathode materials. This colorized image, created using a helium ion microscope, shows a used photocathode electrode obtained from the Thomas Jefferson National Accelerator Facility (JLab). Photocathodes are used to direct high-energy beams, such as X-rays, at samples. Researchers at PNNL have made a first attempt to understand how and why the expensive photocathode materials degrade with repeated use. Knowing more could lead to longer-lasting photocathodes, less down time for maintenance, lower cost of instruments and deeper insight into the particles and forces that make up our universe. Research was funded by PNNL's Laboratory Directed Research and Development initiative in chemical imaging.

Team Members: V. Shutthanandan, Z. Zhu, M.I. Nandasiri, S.V.N.T. Kuchibhatla, S. Thevuthasan, and W.P. Hess from PNNL and M.L. Stutzman, F.E. Hannon, and C. Hernandez-Garcia from JLab.

**Image was captured using instrumentation at EMSL, a DOE national user facility at PNNL, and was colorized by Vaithiyalingam Shutthanandan.*

April 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
31	1 Holy Monday April Fools' Day	2	3 Last Quarter 4:37 U.T.	4	5	6 Yom Hashoah begins at sundown
7	8	9	10 New Moon 9:35 U.T.	11	12	13
14	15	16	17	18	19 First Quarter 12:31 U.T.	20
21	22	23	24	25	26 Full Moon 19:57 U.T.	27
28	29 Earth Day	30	1 Administrative Professionals Day	2	Arbor Day (US)	

MARCH 2013

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MAY 2013

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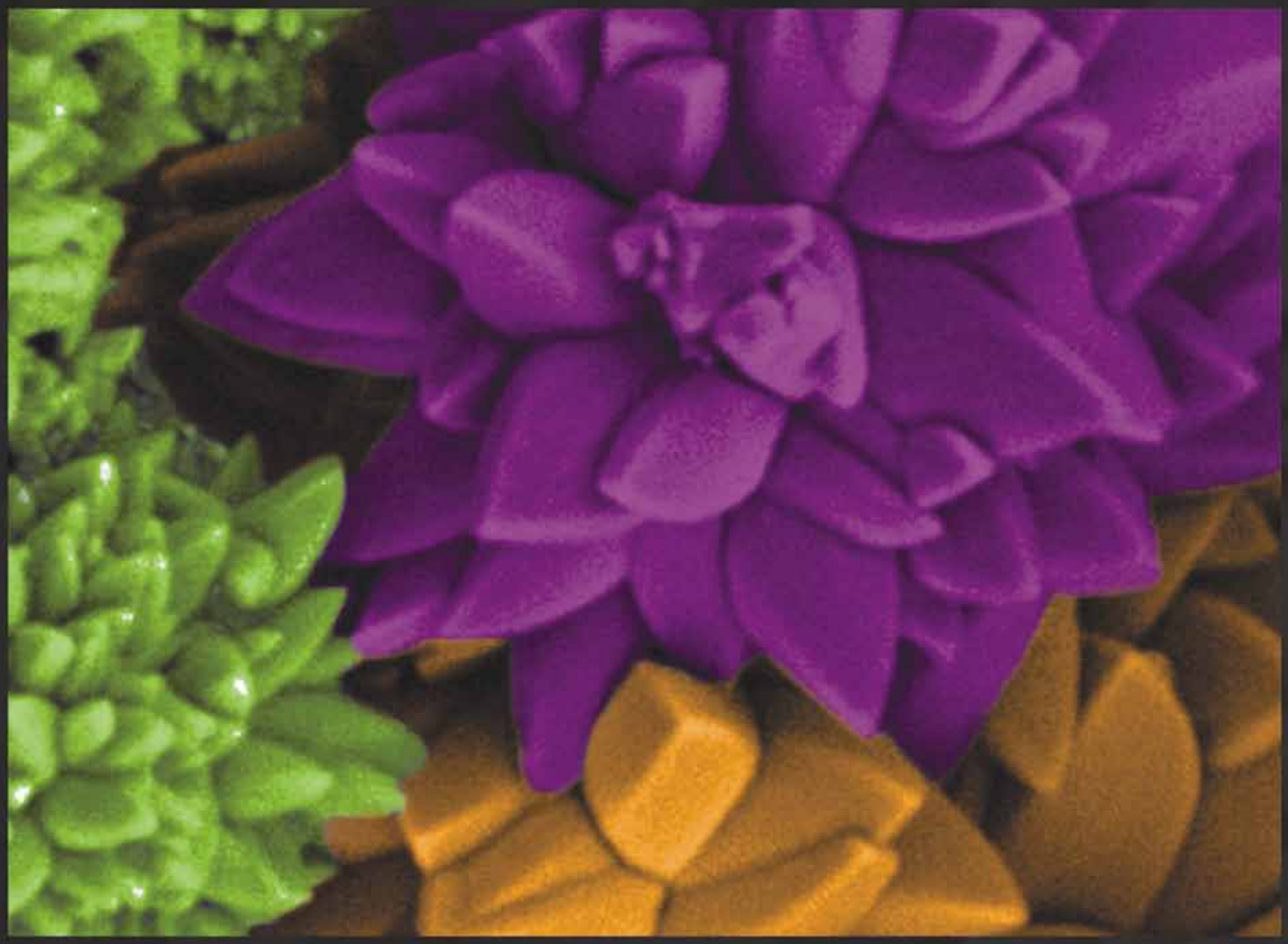

Cooling Buildings More Efficiently

Buildings account for approximately 40 percent of energy consumption in the United States. Adsorption chilling is a method used to cool the air in buildings. It becomes novel and highly efficient when utilizing new materials called super-hydrophilic (water-loving) metal-organic frameworks (HMOFs), like those shown in this image. PNNL researchers have developed HMOFs with porous frameworks, very-high surface areas and other special characteristics. These HMOFs trap unusually high numbers of refrigerant molecules with high sorption capacity and faster kinetics than adsorbents in current chillers, enabling efficient adsorptive chilling applications that require little or no electricity. Research was funded by the U.S. Department of Energy (ARPA-E).

Team Members from PNNL: Radha Kishan Motkuri, Praveen Thallapally, Pete McGrail, and Laxmikant Saraf.

**Image was colorized by Vaithiyalingam Shutthanandan.*

May 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
APRIL 2013 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 2013** 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	30	1 May Day International Workers' Day	2 Last Quarter 11:14 U.T. National Day of Prayer	3	4
5 Pascha (Orthodox) Cinco de Mayo	6	7	8)	9 Ascension	10	11 New Moon 0:29 U.T.
12 Mother's Day	13	14	15	16	17	18 First Quarter 4:35 U.T.
19 Pentecost (Whitsun)	20 Victoria Day (CAN) La Journée nationale des patriotes (QC-CAN)	21	22	23	24	25 Armed Forces Day Full Moon 4:25 U.T.
26	27 Memorial Day (US)	28	29	30	31 Last Quarter 18:58 U.T.	1

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Microstructural Damage in Nuclear Reactor Components

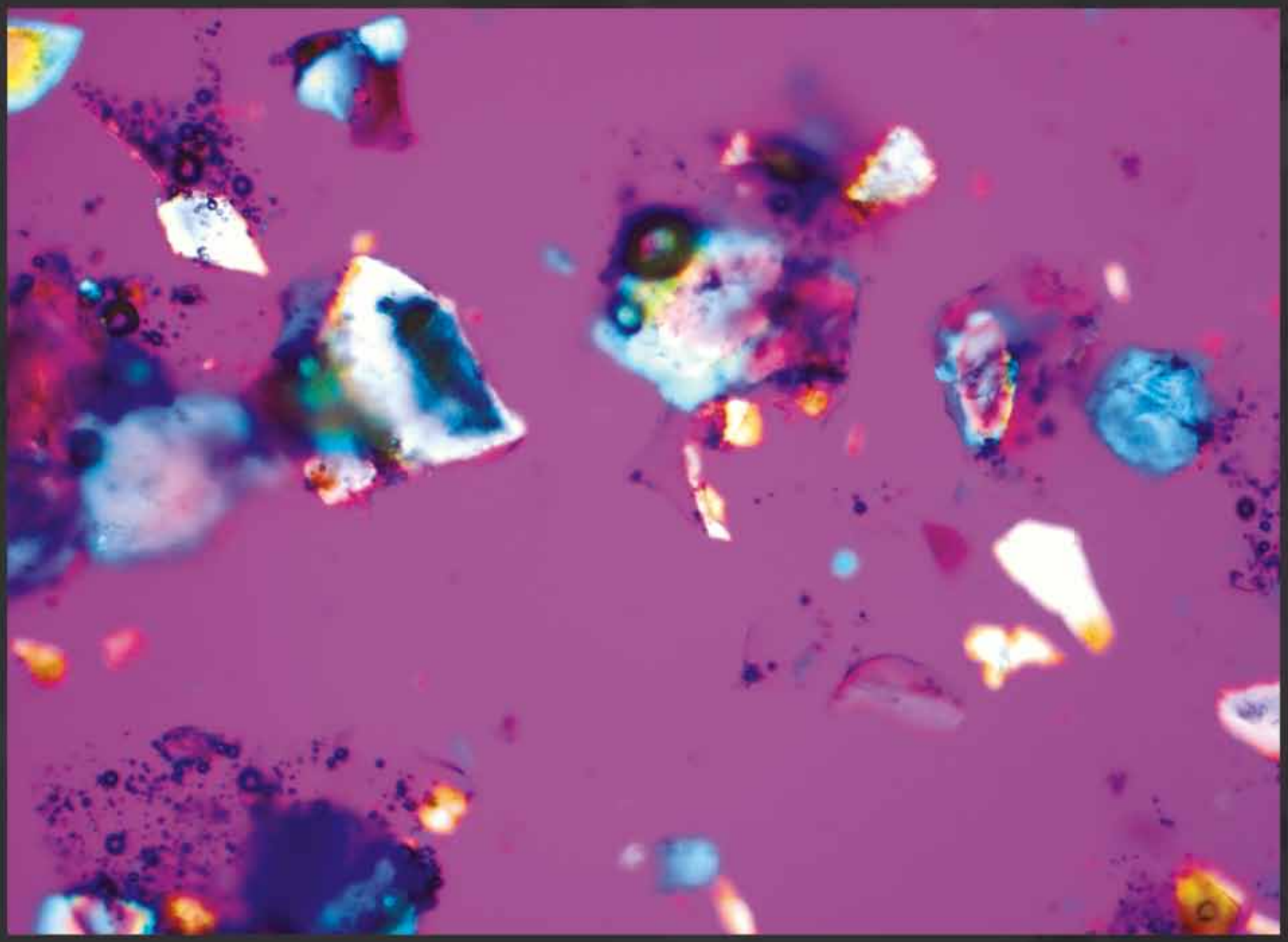
To find, and possibly prevent, weak spots in materials under extreme stress, such as those at the heart of a nuclear reactor, scientists at PNNL are combining detailed macroscopic to microscopic images. This image shows a microscopic picture of a high-chromium, nickel-based alloy. Its surface was chemically etched to reveal faceted crystallographic planes at regions of localized microstructural damage. Through their research, scientists at PNNL are understanding how damage in metallic alloys evolves. This information may help identify failure mechanisms, improve reactor component reliability and extend reactor life. Research was funded by the Nuclear Regulatory Commission and the U.S. Department of Energy.

Team Members from PNNL: Matthew Olszta, Mychailo Toloczko, Dan Schreiber, Rob Seffens, Clyde Chamberlin and Stephen Bruemmer.

**Image was colorized by Matthew Olszta.*

June 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
MAY 2013 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 2013** 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	28	29	30	31	1
2	3	4	5	6	7	8 New Moon 15:56 U.T.
9	10	11	12	13	14	15
16 First Quarter 17:24 U.T.	17	18	19	20	21 Flag Day (US) Summer begins	22
23 Father's Day Full Moon 11:32 U.T.	24	25	26	27	28 National Aboriginal Day Journée internationale des populations autochtones (CAN)	29
30 Last Quarter 4:54 U.T.	Fête nationale du Québec Quebec National Day Saint-Jean Baptiste (QC-CAN) Discovery Day (NL-CAN)					



Learning from the Past to Prevent the Spread of Nuclear Materials

This digital image shows soil particles altered by the world's first nuclear explosion in Alamogordo, N.M., in 1945. Using microscopic imaging tools, scientists at PNNL and the University of Notre Dame rapidly identified the microstructure of crystalline and glassy particles altered by the intense heat of the explosion. This capability identifies and examines forensic information extracted from samples at nuclear blast sites. Research was funded by the National Security Agency.

Team Members: Edgar Buck and Bruce McNamara from PNNL and collaborators at University of Notre Dame.

July 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
30	1 Canada Day Fête du Canada (CAN)	2	3	4 Independence Day (US)	5	6
7	8 New Moon 7:14 U.T. ●	9	10	11	12	13
14	15 Ramadan begins at sundown	16	17 Nunavut Day (NU-CAN) First Quarter 3:18 U.T. ◐	18	19	20
21	22	23 Full Moon 18:15 U.T. ○	24	25	26	27
28	29	30 Last Quarter 17:43 U.T. ◑	31	1		

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AUGUST 2013

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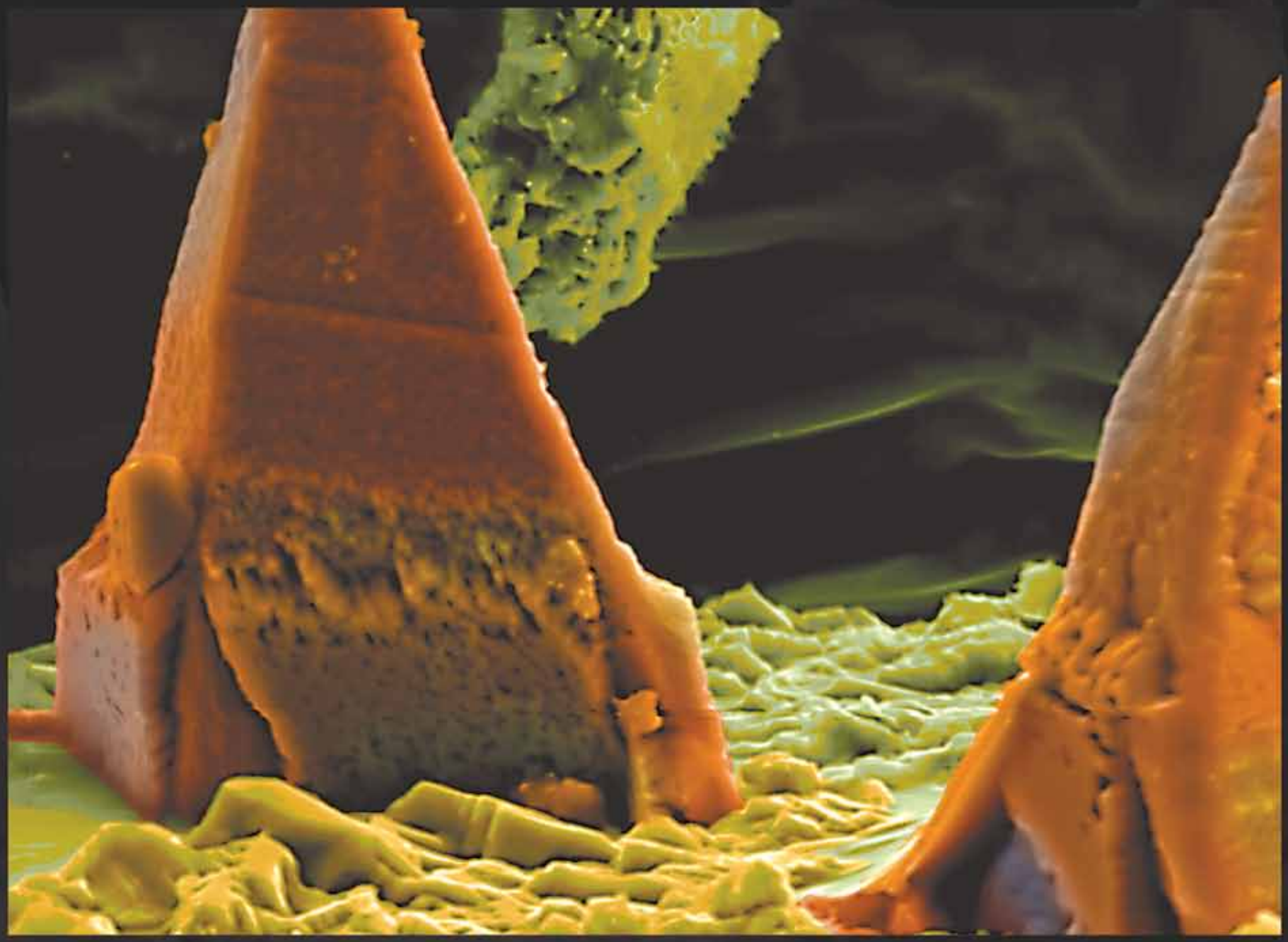

Minerals for CO_2 Capture to Reduce Adverse Effects of Energy Production

Capturing and storing carbon dioxide (CO_2) and other greenhouse gases deep underground is one of the most promising options for reducing the effects of energy production on the earth. Scientists at PNNL are using electron microscopes to understand the reaction of CO_2 and minerals found underground. This picture, taken with an electron microscope, shows the aftermath of fayalite reacting with gaseous CO_2 to form siderite, thereby capturing the CO_2 in a solid, stable form. Research was funded by the U.S. Department of Energy.

Team Members from PNNL: Bruce Arey, Odeta Qafoku and Andy Felmy.

**Image was captured using instrumentation at EMSL, a DOE national user facility at PNNL, and was colorized by Nathan Johnson.*

August 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JULY 2013 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 2013** 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	30	31	1	2	3
4	5 Civic Holiday Congé civique (CAN)	6	7 New Moon 21:51 U.T.	8	9	10
11	12	13	14 Eid al-Fitr begins at sundown	15 First Quarter 10:56 U.T.	16	17
18	19	20	21	22 Full Moon 1:45 U.T.	23 Assumption	24
25	26 Discovery Day (YT-CAN)	27	28	29 Last Quarter 9:35 U.T.	30	31

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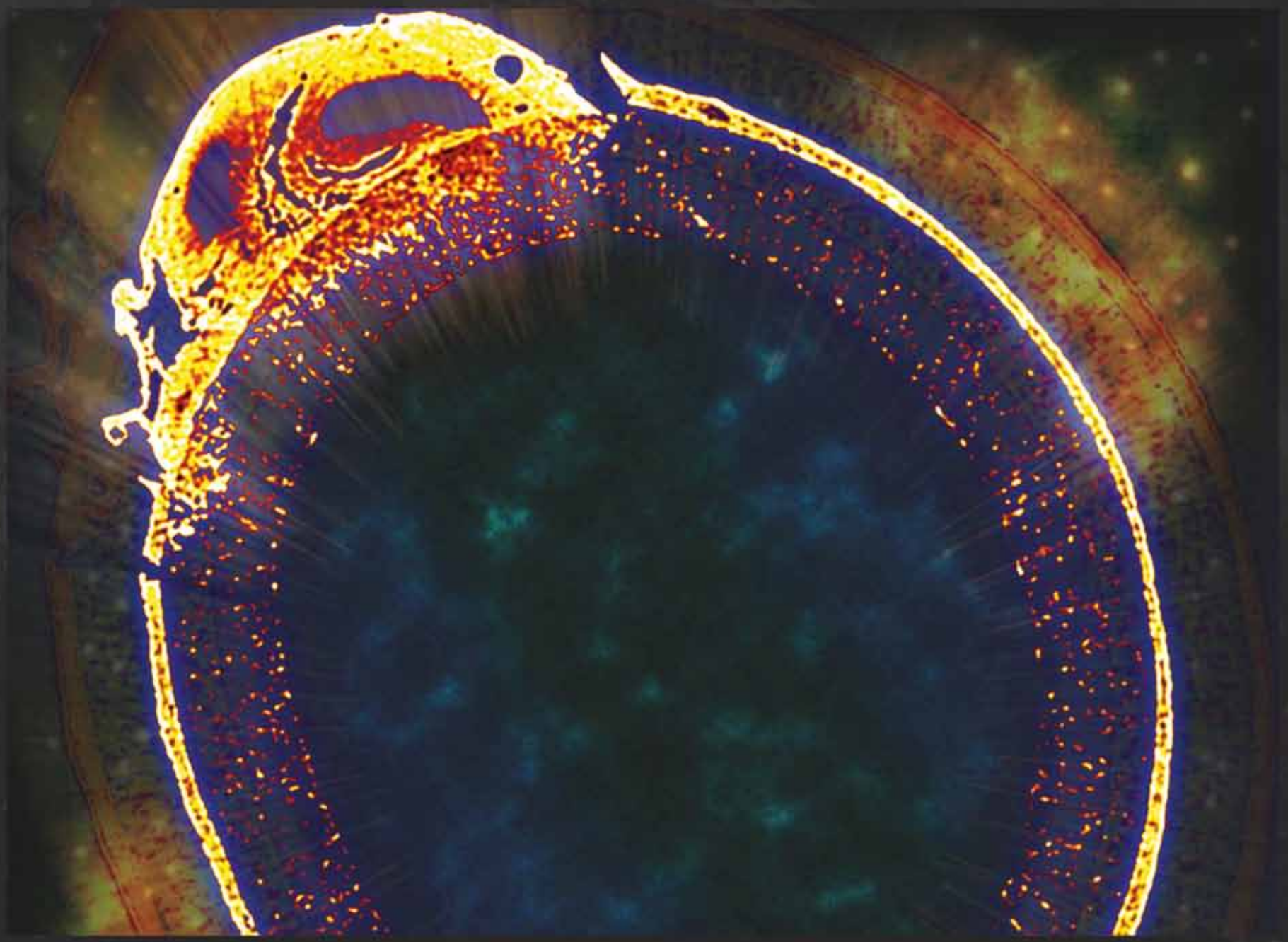

Learning How Microbes do Chemistry

Researchers at PNNL are characterizing chemical and physical interactions of biofilms produced by microbes. This information is used to provide insight on how the tiny microorganisms influence much larger reactions and processes, such as the migration of chemicals and radionuclides underground. To study biofilms, the researchers first obtain detailed microscopic images and chemical information. The image above, obtained using X-ray microtomography, shows a slice of a biofilm grown on a very small porous, hollow fiber. Research was funded by PNNL's Laboratory Directed Research and Development initiative in chemical imaging.

Team Members from PNNL: Mathew Thomas, Erin Miller, James Carson and Matthew Marshall.

**Image was captured using instrumentation at Advanced Photon Source, a DOE national user facility at Argonne National Laboratory, and colorized by Cortland Johnson.*

September 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1	2	3	4	5 New Moon 11:36 U.T.	6	7
8	9 Labor Day (US) Labour Day Fête du Travail (CAN)	10	11 Rosh Hashanah begins at sundown	12 First Quarter 17:08 U.T.	13	14
15 National Grandparents Day	16	17	18 9/11 Remembrance	19 Full Moon 11:13 U.T.	20 Yom Kippur begins at sundown	21
22 Autumn begins	23	24	25	26	27 Last Quarter 3:56 U.T.	28 UN International Day of Peace
29	30	1	2	3		

AUGUST 2013

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OCTOBER 2013

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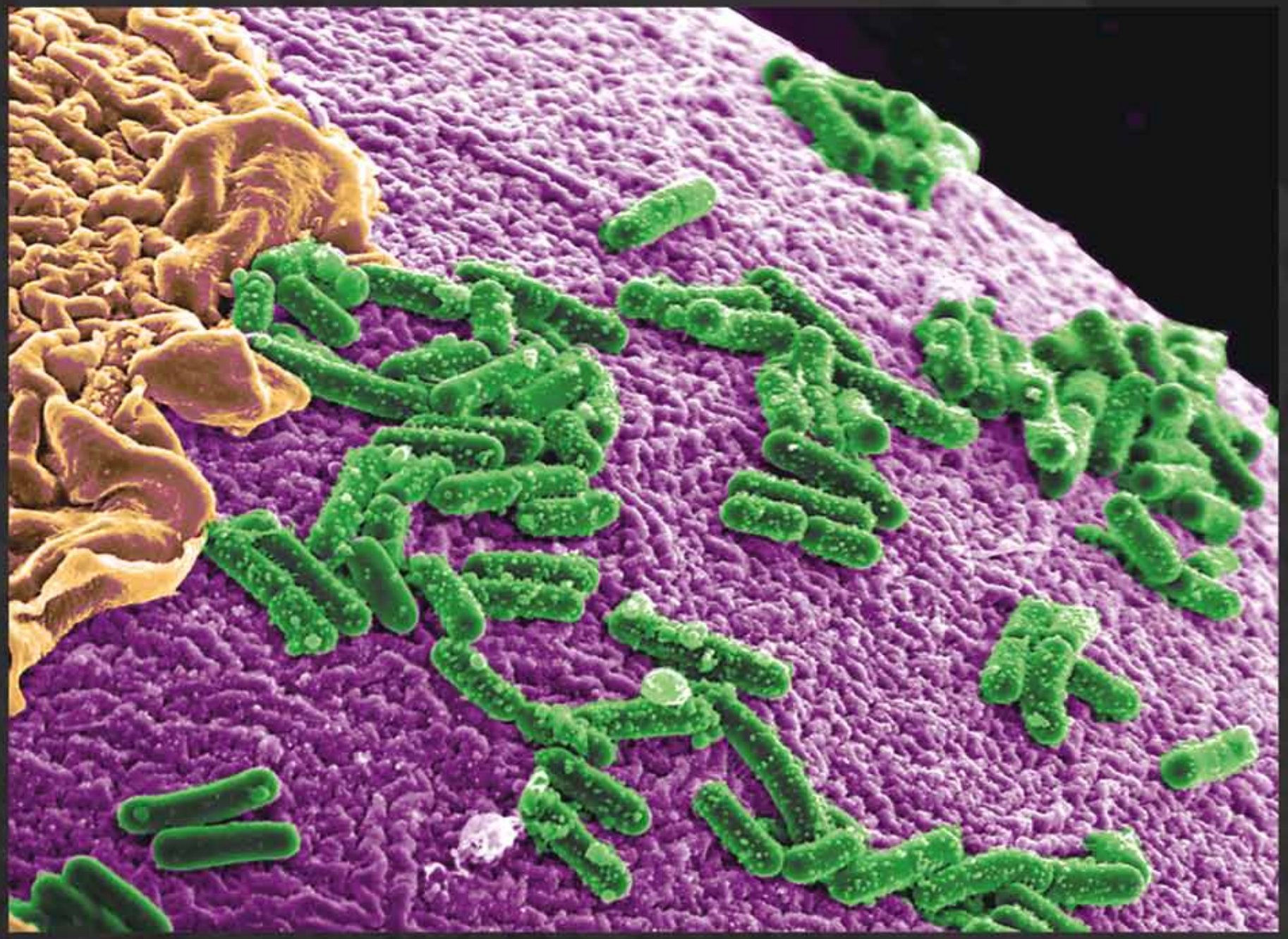

Improving Human Intestinal Health

Scientists at PNNL are developing a model of the microbial environment inside the human gut. This model is composed of three-dimensional human intestinal cells cultured with specific gut bacteria. Changes in certain bacterial populations within the gut have been attributed to colon cancer, obesity, type 2 diabetes, and neurological diseases such as Alzheimer's and Huntington's diseases. The three-dimensional model provides an approach to study how changes in bacteria affect gut health and overall human health. Research was funded by the U.S. Department of Health and Human Services and PNNL's Laboratory Directed Research and Development initiative in chemical imaging.

Team Members from PNNL: Janine Hutchison, Alice Dohnalkova, Becky Hess, Helen Kreuzer and Timothy Straub.

**Image was colorized by Chad Marrington.*

October 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
29	30	1	2	3	4	5 New Moon 0:35 U.T.
6	7	8	9	10	11 World Animal Day First Quarter 23:02 U.T.	12
13	14	15	16	17	18 Full Moon 23:38 U.T.	19
20	21 Thanksgiving Day Action de grâce (CAN) Columbus Day (US) Eid al-Adha begins at sundown	22	23 National Boss's Day	24	25	26 Last Quarter 23:41 U.T.
27	28	29	30	31 United Nations Day Halloween		

SEPTEMBER 2013

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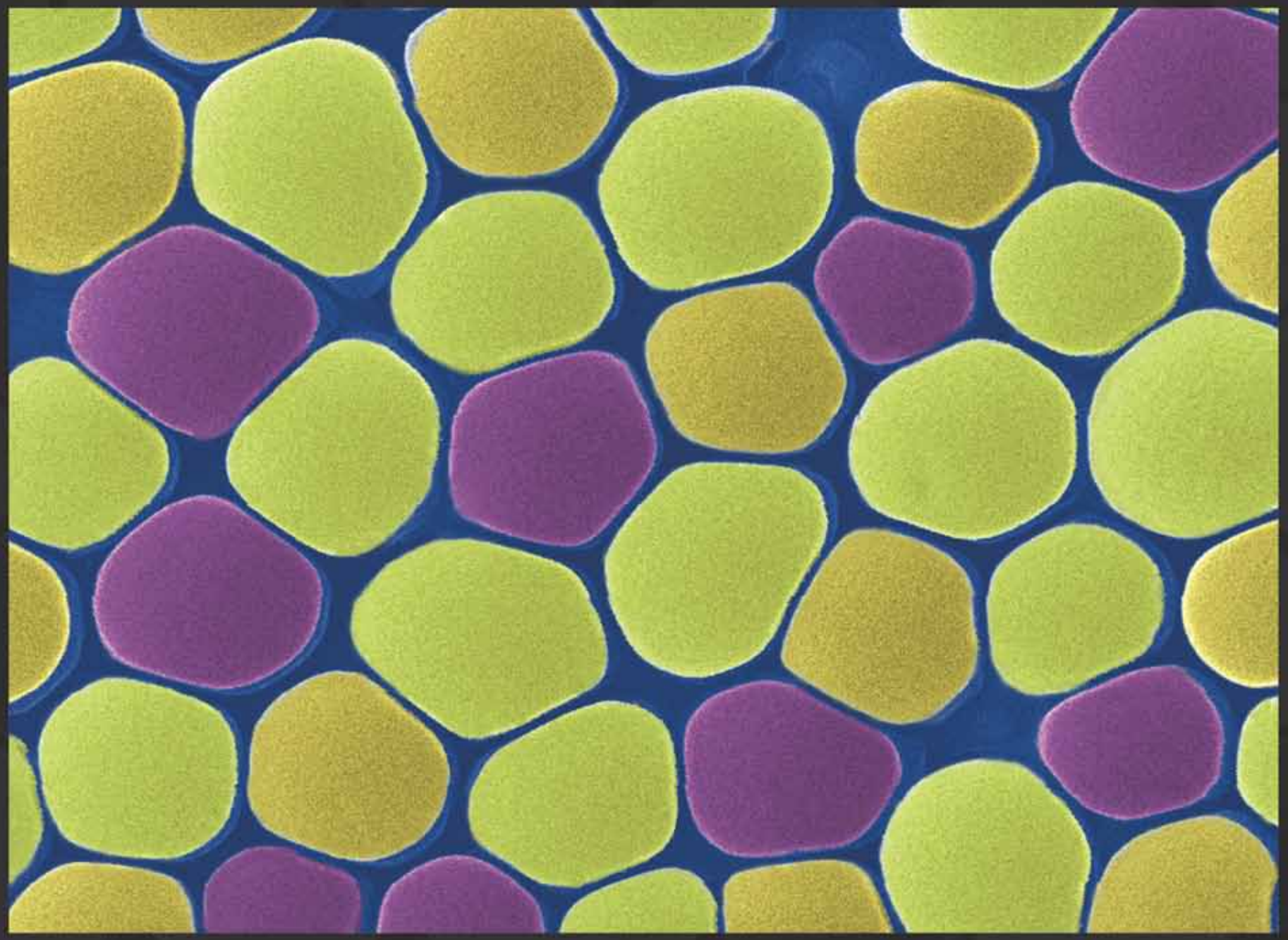

Capturing the Energy of the Sun

This helium ion microscopic image shows the back side of an array of titanium dioxide (titania) nanotubes grown by the controlled corrosion of titanium metal. Titania is a versatile transition metal oxide that is used in gas sensors, photocatalysis and dye-sensitized solar-cell applications. PNNL researchers and collaborators are using helium-ion images of titania nanotube arrays to improve understanding of the material's performance in dye-sensitized solar cells. Dye-sensitized solar cells are used for converting solar energy into electricity, thereby helping to reduce the nation's dependence on imported oil. Research was funded by the National Science Foundation and the U.S. Department of Energy.

Team Members: Ajay S. Karakoti, Vaithiyalingam Shutthanandan, Satyanarayana Kuchibhatla and Suntharampillai Thevuthasan from PNNL and Sudipta Seal from the University of Central Florida.

**Image was captured using instrumentation at EMSL, a DOE national user facility at PNNL, and colorized by Vaithiyalingam Shutthanandan.*

November 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
OCTOBER 2013 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	**DECEMBER 2013** 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	29	30	31	1 All Saints' Day	2 All Souls' Day
3 New Moon 12:50 U.T.	4	5	6	7	8	9
10 Daylight Saving Time ends First Quarter 5:57 U.T.	11	12	13 Election Day (US)	14	15	16
17 Full Moon 15:16 U.T.	18 Veterans' Day (US) Remembrance Day (AU; CAN) Jour du Souvenir (CAN)	19	20	21	22	23
24	25	26 Last Quarter 19:28 U.T.	27 Hanukkah begins at sundown	28 Thanksgiving Day (US)	29	30

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Clean Sustainable Energy from Coal

Removing carbon dioxide (CO_2) from the gases emitted by coal-fired and other fossil-fueled power plants requires materials that can efficiently extract the CO_2 while ignoring the other gaseous molecules. These materials must be capable of working in hot, moist environments without losing efficiency. PNNL researchers modified the surface of a material called a metal-organic framework (MOF) to render it better able to extract CO_2 under the working conditions it might encounter. The MOF shown above was imaged at 20,000 times magnification using a focused ion beam scanning electron microscope. The proposed surface modification may be applicable to thousands of different MOF materials to improve moisture stability and increase selectivity towards CO_2 extraction. This work will help to make fossil energy use more sustainable, safer and cleaner. Research was funded by the U.S. Department of Energy.

Team Members from PNNL: Carlos Fernandez, Laxmikant Saraf, Praveen Thallapally and Pete McGrail.

**Image was captured using resources at EMSL, a DOE national user facility at PNNL, and colored by Cortland Johnson.*

December 2013

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
1	2	3 New Moon 0:22 U.T.	4	5	6	7
8 Advent	9 First Quarter 15:12 U.T.	10	11	12	13	14 Pearl Harbor Remembrance
15	16	17 Full Moon 9:28 U.T.	18	19	20	21 Winter begins
22	23	24	25 Last Quarter 13:48 U.T.	26 Kwanzaa begins St. Stephen's Day Boxing Day (CAN) Le lendemain de Noël	27	28
29	30	31 Christmas Eve New Year's Eve	1 Christmas Day	2		

NOVEMBER 2013

					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 2014

			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	

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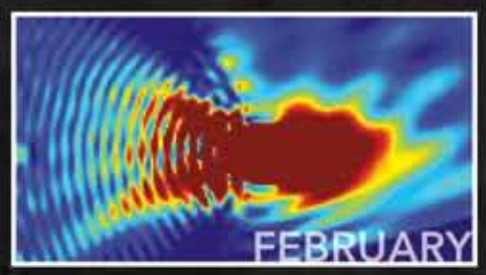

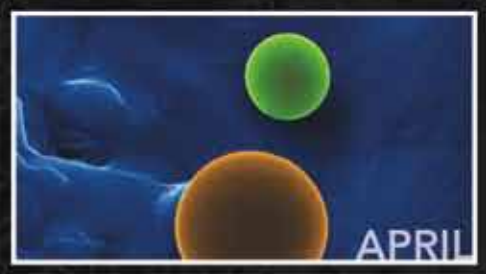

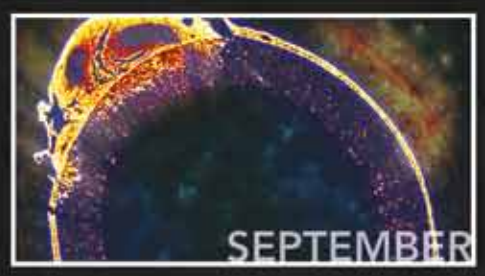

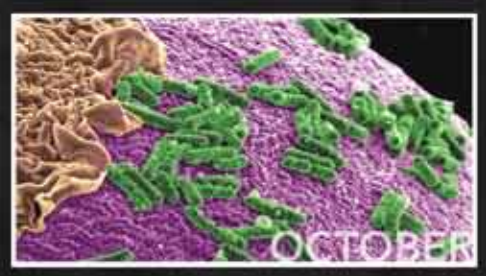

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DISCOVERY *in Action*

Researchers at Pacific Northwest National Laboratory (PNNL) in Washington state create beautiful works of art every day in the course of their scientific endeavors.

As one of the U. S. Department of Energy's largest national laboratories, staff members at PNNL collaborate amongst themselves and with university, industry and other national laboratory partners. Together, they advance science and solve complex programs in energy, the environment, and national security and move new technology solutions to market.

Images contained within this calendar were captured as part of PNNL's third annual Science as Art contest held in 2012.

We hope you enjoy reading the stories behind each image, which illustrate how PNNL is contributing to the safety, security and prosperity of our nation.

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