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Sandians answer the call
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Burping bacteria: Identifying Arctic microbes that produce methane

CHILL SCIENCE — Sandia technologist Jenna Schambach working with a sample of Alaska lakebed soil. By studying the microbes in the soil, and the gases they emit, Jenna and project lead Chuck Smallwood hope to improve understanding of the rapidly melting Arctic permafrost and improve computer models of climate change. **Photo by Craig Fritz**

Scientists study soil and gas samples to improve climate models

By **Mollie Rappe**

As greenhouse gases bubble up across the rapidly thawing Arctic, Sandia researchers are trying to identify other trace gases from soil microbes that could shed some light on what is occurring biologically in the melting permafrost.

Sandia bioengineer Chuck Smallwood and his team recently spent five days collecting lakebed soil and gas samples. They were joined by international

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Navigating when GPS goes dark

High-tech sensors could guide vehicles without satellites, if they can handle the ride

By **Troy Rummler**

Words like "tough" or "rugged" are rarely associated with a quantum inertial sensor. The remarkable scientific instrument can measure motion a thousand times more accurately than the devices that help navigate today's missiles, aircraft and drones. But its delicate, table-sized array of components that includes a complex laser and vacuum system has largely kept the technology grounded and confined to the controlled settings of a lab.

Jongmin Lee wants to change that.

The atomic physicist is part of a team at Sandia that envisions quantum inertial sensors as revolutionary, onboard navigational aids. If the team can reengineer the sensor into a compact, rugged device, the technology could safely guide vehicles where GPS signals are jammed or lost.

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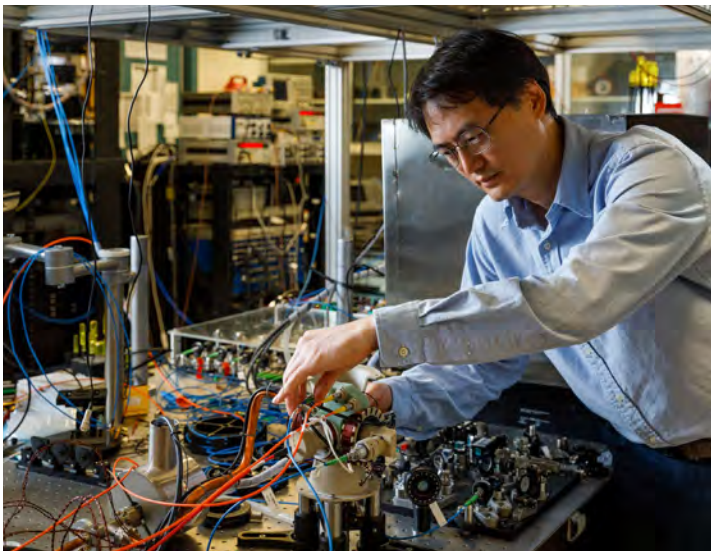

TOUGH ENOUGH? — Sandia atomic physicist Jongmin Lee examines the sensor head of a cold-atom interferometer that could help vehicles stay on course where GPS is unavailable. **Photo by Bret Latter**

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Lab News may contain photos shot prior to current COVID-19 policies. Individuals in photos followed all social distancing and masking guidelines that were in place when photos were taken.

EDITOR'S NOTE: Please send your comments and suggestions for stories or for improving the paper. If you have a column (500-800 words) or an idea to submit, contact Lab News editor Katherine Beherec at kgbeher@sandia.gov.

Life at the Red Shack

PREPPING GROUND ZERO — Freddie Hidalgo stands at ground zero during preparation for an underground test at the Nevada Test Site in 1990. Right before the photo was taken, the device pedestal that sits at the bottom of the diagnostics package had been lowered into the device can, which was suspended at the top of the vertical shaft and protected the device as the diagnostics package was lowered into the shaft. Behind Freddie, the device can is fitted to the diagnostic package.

Photo courtesy of Lawrence Livermore National Laboratory

Freddie Hidalgo recounts his time working on underground nuclear weapons tests

By **Kristen Meub**

In 1986, Freddie Hidalgo joined a small, elite team of Sandia engineers and technicians responsible for arming and firing nuclear devices during underground tests at the Nevada Test Site. By the end of 1991, Freddie had worked on 12 weapons tests, each one requiring three to six months of intense on-site preparation and staging. This fall marks the 30th anniversary of the last nuclear weapons test, code-named Divider, conducted by the U.S. It was the last of 1,032 nuclear tests done over 47 years. To mark the anniversary, Lab News interviewed Freddie about his experience working in the nuclear test program.

Life at the test site

As a member of the arming and firing team, nicknamed A&Fers, Freddie was responsible for arming and firing "the device" and multiple fast-action closures designed by Sandia. His team

supported Lawrence Livermore National Laboratory-led tests, 10 of which were shots where the device was lowered into vertical shafts located 800 to 2,200 feet underground. The other two tests were horizontal shots, conducted inside of tunnels at Area 12 of the test site.

While his team had fewer than 15 members, Freddie recalls the test site employing close to 10,000 people and running hundreds of buses daily to the test site, located in a Rhode Island-sized section of desert north of Las Vegas and south of Tonopah Test Range.

"For tunnel shots, we were basically miners at the time; it was like being one of the seven dwarfs," Freddie said. "We'd ride these little miner trains, wearing our hard hats in preparation for working in dark and small spaces. Hopefully, you would never miss a morning, lunch or evening train to your alcove, otherwise it could be a long 25-minute walk through the tunnels."

Prior to a vertical test, Freddie's team prepared the arming and firing pedestal, which was about 6 feet wide and 3 feet tall. The team hardwired the different components that were used to set off the device. They also staged the Red Shack, a specially configured metal trailer that housed arming and firing power supplies and equipment needed to fire the device.

"Once the Red Shack was ready to go, we'd start doing daily dry runs to exercise the system without firing the device to make sure that everything was functioning as planned," Freddie said. "On D minus one, the day before the test, we'd do our final dry run in a full power and full frequency configuration. If you had left a coffee pot plugged in or a light switch turned on in the Red Shack or any of the many diagnostic trailers, you didn't touch it or turn it off until after the test. From an electrical standpoint, everything needed to be exactly the same for the morning of the test."

Freddie also recalls performing K duty, the nickname for a technical and safety protocol required whenever a nuclear device was present.

"You always had to have two people there who were knowledgeable about every aspect of the operations," he said. "When you were on K duty, you weren't allowed to do any technical work. Instead, you had to watch those performing the work and make sure it was being done correctly and safely. K duty was an enormous responsibility, and there was never a dull moment."

After the pre-arming operation was complete for a tunnel shot, workers would fill the ground zero alcove from floor to ceiling with sandbags. For one test, Freddie was on K duty and was the last person to exit the 12-by-12-foot alcove through a small opening near the ceiling. The tunnel workers had to carry him above their heads as he crawled out from the opening, like body surfing at a concert.

Permission to arm

At 2 a.m. on the morning of a test, the arming and firing team would wake up in their bunks adjacent to the control room. After a briefing, the team would drive for more than an hour to ground zero in a guarded convoy with security lights flashing. There, they would complete dozens of electrical checks and then play cards, eat popcorn and wait for a final call to be relayed from Las Vegas to the test director to the Red Shack through a red phone wired directly to the control room.

The call would give "permission to arm," during which the team would remove the firing cables from a two-person-controlled, double-keyed lock box and proceed to connect them to the Zero Rack, a large relay chassis, and perform one last electrical verification before taking another long drive

THE RED SHACK — Freddie Hidalgo stands outside of the arming and firing trailer, nicknamed the Red Shack, at the Nevada Test Site in 1988. Freddie said the trailer sat on top of foam blocks that were used as shock absorbers. During the shot, the blocks would flatten, and the trailer would land on the ground. In the photo on the left, the diagnostic tower is behind the Red Shack. The tower was several stories high and housed the diagnostic package, which included experiments, the arming and firing pedestal and the device pedestal. **Photos courtesy of Lawrence Livermore National Laboratory**

THEN AND NOW — Engineer and manager Freddie Hidalgo recounts his experiences in nuclear testing while working at the Nevada Test Site. This fall marks the 30th anniversary of the last nuclear weapons test, code named Divider. Today, Freddie manages a product realization team that designs weapon components for the W80-4. **Photo by Craig Fritz**

through the desert back to the control room. After daylight, usually by 8 a.m., the countdown would start. The team would remain in the control room to ensure that all items associated with the arming sequence occurred as planned and ultimately resulted with the fire signal being sent to detonate the device.

About 20 seconds after detonation, the control room located 10 to 40 miles away from ground zero would start to shake, similar to an earthquake. For some tests, the shock wave could be felt in Las Vegas. At ground zero, the shock wave would immediately hit the trailer park that housed the diagnostic trailers, the timing station and Red Shack, throwing all of them up in the air. The trailers would land on specially configured stacks of foam blocks that would crush and flatten as they absorbed the impact.

Executing the mission, then and now

The last test Freddie worked on, codenamed Bristol, was in November of 1991. With the moratorium on nuclear weapons testing on the horizon, Freddie moved to Albuquerque to work with NNSA's Office of Safeguards and Transportation. He started his new role as an engineer for the OST Relay Stations, then supported nuclear weapon security programs as a Sandia project lead.

Later, he worked in the private sector for 10 years before returning to Sandia to support B61-12. Today, he manages a product realization team that designs weapon interconnect components for the W80-4. While a lot has changed in 35 years, he said that the call to support Sandia's mission remains strong.

"Back then we dreamed big, and I think today Sandians are still dreaming big. A lot has changed, but the heart of the people, their drive to execute the mission, is one stitch that holds us all together," he said. "For me, it's knowing the importance of the nation's nuclear deterrent in keeping the world and our country safe that motivates me to get up every morning."

From nuclear testing to stockpile stewardship

By **Rebecca Ullrich, Sandia historian**

Nuclear testing

Beginning with Trinity, when they were still part of Los Alamos, Sandians were involved in every nuclear test the U.S. did — both tests for weapon designs and weapon effects for the DOD. Sandia was responsible for assembly, arming and firing; for experiments and data capture that verified Sandia-designed components and how subsystems worked; for data capture for weapon effects, including seismic effects, radiation effects and more; for blast effects studies; for experimental setups in support of studying weapon effects; and for any number of other preparations for and analysis of the test shots.

The first postwar test series was Operation Crossroads in 1946 in the Pacific. The United States continued testing at the Pacific Proving Ground and, beginning in 1951, at the Nevada Test Site. In 1963, the Limited Test Ban Treaty brought atmospheric and underwater testing to an end, moving all full-scale testing underground.

End of testing

The end of the Cold War shifted thinking about nuclear weapons development and testing. The Soviet Union announced a one-year unilateral moratorium on testing on Oct. 5, 1991.

On May 10, 1992, Secretary of Energy Adm. James Watkins testified before the Senate Armed Services Committee that for the first time since 1945, the U.S. did not have any new nuclear weapons in design. A few months later on Sept. 23, the U.S. conducted Divider, the last nuclear weapons test at the Nevada Test Site.

On Oct. 2, 1992, President George H. W. Bush signed legislation that included the Hatfield Amendment, which established a U.S. moratorium on nuclear testing. A few weeks later, Russia extended its moratorium. In 1993, President Bill Clinton extended the U.S. moratorium through September 1994 and then again through September 1996.

In April 1993, Clinton and President Boris Yeltsin of Russia agreed to pursue a multilateral test ban. In August 1995, Clinton announced negotiations for the Comprehensive Test Ban Treaty.

Stockpile stewardship program

When he announced that the U.S. would pursue negotiations for the Comprehensive Test Ban Treaty with its allies and Russia, Clinton also revealed the plan to pursue science-based stockpile stewardship to replace nuclear testing. The treaty was signed on Sept. 24, 1996, but has not been ratified by Congress. Still, there is currently no expectation that the U.S. will return to nuclear testing.

Vic Reis, assistant director of Defense Programs at the time, is credited with architecting stockpile stewardship. Discussions of it and specific preparations for it, such as detailed outlines of what it would entail, were underway long before Clinton's announcement. For example, former Sandia Vice President Roger Hagengruber participated in developing the program.

Sandia had done stockpile surveillance before 1992, but the halt in nuclear testing altered this into a much bigger vision and practice. All three nuclear laboratories moved from checking items in the stockpile regularly, including pulling weapons out and fully testing them, to using modeling and simulation to assert the safety, security and reliability of the stockpile. The requirement was to test existing designs and any modifications to them without explosive nuclear testing. An additional requirement is that each director of the weapons laboratories must annually certify the safety, security and reliability of the stockpile.

As part of stockpile stewardship, all three weapons labs were funded through the Accelerated Strategic Computing Initiative, a focused initiative to pursue modeling and simulation. Under ASCI, Sandia first partnered with Intel to develop ASCI Red, the world's first teraflop supercomputer, which became fully operational in 1996. Since then, all three nuclear laboratories have developed successful machines advanced by the stockpile stewardship initiative. This has resulted in massive leaps in computer design and performance, as well as the extension of that computing power to areas beyond nuclear weapons design and testing.

The Stockpile Stewardship Program is considered a success. The Life Extension Programs are reaching production under it, and the new W93 will be dependent upon it.

Want more history?

- **DOE's 20th-anniversary article on stockpile stewardship**
- **The Research Magazine article on stockpile stewardship**: The section on a "A different kind of testing" provides a good summary of the stockpile stewardship program.
- **Cold War Warriors**: This documentary is the story of countless nuclear weapons workers at Sandia Corp. who worked in all aspects of Sandia's above ground, atmospheric and underground nuclear weapons field test operations from the dawn of the atomic age in 1945 to the cessation of testing in 1992. "A lot of the Sandians interviewed in this documentary were my mentors and the people I worked with," Freddie said.

More benefit choices for 2023

Employees encouraged to enroll for benefits before Nov. 9

By **Shelley Kleinschmidt**

It's that time of year: employees' yearly opportunity to review and change their benefits and the dependents they cover for the upcoming year. Sandia encourages employees to learn what's new for 2023 to ensure they make informed benefit choices during Open Enrollment, now underway through Nov. 9.

"We've heard from employees that they want more benefit choices, more ways to save money and added support for what's important to them," said Executive Director and Chief Human Resources Officer Brian Carter. "We listened to employees, and during last year's enrollment, we introduced a new medical plan option: the Health Savings Plan with the companion health savings account. For 2023, we're offering more choices for dental and vision coverage. We're also excited to introduce a new lifestyle spending account that gives non represented, benefits-eligible Sandians up to $500 each year to spend on a variety of lifestyle expenses. The account covers everything from pet care to gym memberships to moving expenses to tax preparation services." If you are a represented employee, refer to your collective bargaining agreement to verify your benefit options.

Same medical plan options for 2023

For medical coverage, employees will continue to choose between the Health Savings Plan and the Total Health PPO Plan. Sandia has made some changes to the design of the Health Savings Plan to comply with IRS regulations and has eliminated the $100 minimum contribution to the plan's companion health savings account.

Expanded dental and vision options

Employees will have three dental plans and three vision plans to choose from — and each will offer four coverage tiers. For both dental and vision, Sandia is adding two more plans: one with enhanced coverage and the other with more basic coverage. The plans with more comprehensive coverage cost more

OPEN ENROLLMENT 2023 — This year, an enhanced decision-making tool helps employees compare medical plans to determine the best fit for them and their families. Open enrollment runs through Nov. 9. **Photo by Craig Fritz**

than the plans offering more limited coverage. Additionally, for dental and vision, employees can choose the best coverage tier for them: employee only, employee and one or more children, employee and spouse, or employee with spouse and one or more children.

New lifestyle spending account fully funded by Sandia

Eligible employees can receive up to $500 in reimbursements for various lifestyle services and programs each year. Non represented, benefits-eligible Sandians, excluding students, will be automatically enrolled in this account on Jan. 1. Employees can get a preview of what's covered to help them plan ahead.

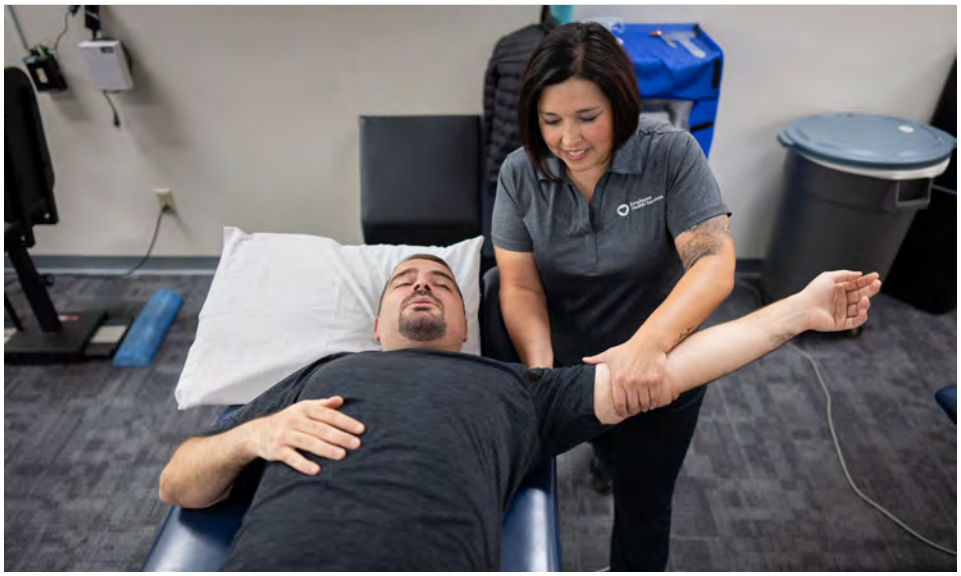
Mark the date: Open Enrollment begins Oct. 19

"We encourage employees to review their options for 2023 and to look closely at their personal situation and anticipated healthcare needs for the next year," Brian said. "We also want employees to take advantage of the resources available at hr.sandia.gov and choose the coverage that will best meet their immediate and long-term needs."

How to enroll

To enroll, visit hr.sandia.gov and choose HR Self Service. To make elections from home or a mobile device, an employee needs a CryptoCard, HSPD-12, PIV-C or mobile credential.

The elections employees make during open enrollment are effective from Jan. 1 through Dec. 31, 2023. Employees who want to participate in a health care or dependent care flexible spending account or buy or sell vacation for 2023 must make their elections by Nov. 9 at 6 p.m. MST.



PLANNING AHEAD — During Open Enrollment, Sandians can choose medical, dental, and vision plans options and buy or sell vacation. Open Enrollment continues through Nov. 9.

Photo by Craig Fritz

Enhanced tool helps compare medical plans

Employees can use an enhanced, interactive medical plan comparison tool to help them select their medical plan option for 2023. The benefits management team first approached systems analyst Jeff Gruda, which sparked a collaborative effort between system analysts in End User Solutions, User Experience Solutions Group, the EBI Management Organization and Benefits. The team developed a tool that allows employees to run scenarios that compare their out-of-pocket costs between the Health Savings Plan and the Total Health PPO Plan. Employees enter their salary range, the number of dependents covered, how much they plan to contribute to the healthcare spending accounts and their estimated medical and prescription drug expenses to estimate the impact on their wallet under each plan.

Employees can enter as many scenarios as they wish. The comparison tool does not save, access or import personal information about employees and their dependents.

Employees can access the comparison tool from the EBI Portal. Navigate to HR, then Benefits and select Medical Plan Comparison Tool.

Additional resources to help employees choose

- **2023 Benefits Guide**: A comprehensive summary of benefit options.
- **2023 Open Enrollment News**: Highlights enrollment process and includes a comprehensive enrollment checklist.
- **Medical**, **dental** and **vision** plan comparison charts: Charts that detail the coverage available under each plan option.
- **Monthly premiums for 2023**: A table that shows monthly rates for each coverage option.
- **Health Savings Plan video**: Information about all the features of the Health Savings Plan, including the tax-advantaged health savings account.
- **Medical Plan Options video**: Compares the Health Savings Plan and the Total Health PPO Plan.
- Benefits website: More information about benefit options at **hr.sandia.gov**.

Burping bacteria

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collaborators led by professor Katey Walter Anthony from the University of Alaska, Fairbanks, including researchers from the University of Colorado, Boulder; University of Quebec in Rimouski and Ben-Gurion University of the Negev in Israel.

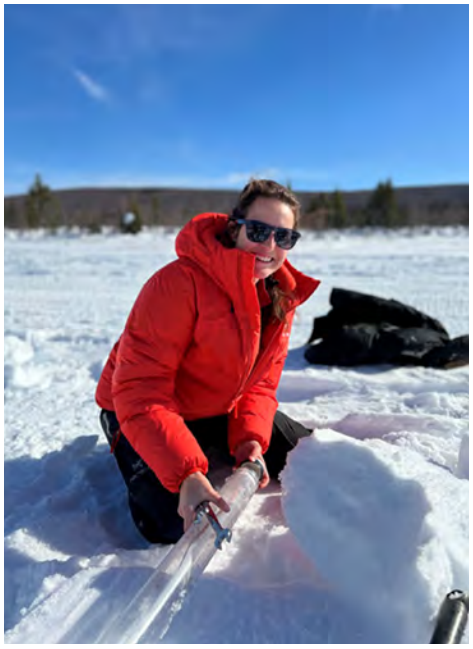
"The Arctic is rapidly changing, releasing large amounts of greenhouse gases; we just don't know how much greenhouse gases are released every year," Chuck said. "Our work at Sandia seeks to improve our understanding of how much greenhouse gases soil microbes are producing, without going out and destructively sampling permafrost soils. The goal is to use sensitive gas detection devices to sample microbial volatile compounds coming out with the methane and CO_2 gases instead."

Both methane and carbon dioxide are greenhouse gases, and methane actually traps more heat in the atmosphere than the commonly discussed carbon dioxide. In fact, it is 30 times more potent than carbon dioxide, Chuck said.

Collecting samples of soil and microbes

To measure rates of microbial activity in permafrost soil systems, Chuck's team partnered with the University of Alaska, Fairbanks team to collect their first permafrost samples in late March at two frozen lakes formed from thawing permafrost about 20 minutes north of Fairbanks, Alaska. They also collected samples this September. Next year, they plan to collect samples from thawing coastal marshlands near Oliktok Point on the North Slope of Alaska.

To collect a soil sample from a lakebed, first a member of the University of Alaska, Fairbanks team would put on a harness connected to a rope and walk out onto the frozen lake to clear snow from the frozen lake surface and check



CHANGING CLIMATE — Jenna Schambach preparing a sampling core on an Arctic microbe sampling trip in Alaska. "One of the worries we had going in was it being really, really cold," Jenna said. "Thankfully it wasn't; we weren't cold the whole trip. It was sad too because March in Alaska should be near zero degrees Fahrenheit and it was 35 degrees." **Photo by Tess Hogancamp**

for signs of thin ice, Chuck said. Then the researchers would prepare the site by using a chainsaw to cut down through three or four feet of ice to remove huge ice cubes.

The team would then position one of two coring apparatuses over and around the hole in the ice, Chuck said. One apparatus provided by University of Alaska, Fairbanks scientist Chris Maio, called a hammer corer, could collect 3-foot-long samples while another, called a Vibracore sampler, could collect deeper samples, up to 13 feet.

The Vibracore drilling apparatus contained a long 3-inch-diameter tube that would rapidly vibrate through the lake, down into the lakebed. Using suction — similar to a child playing around with a straw and their finger to suck up soda — the researchers could remove 3- to 10-foot-long cylindrical "cores" of lakebed soil containing microbes that have lived there for hundreds to thousands of years.

These core samples were frozen and shipped to New Mexico for Sandia technologists Jenna Schambach and Bryce Ricken to extract microbes, including bacteria and archaea. Archaea are single-celled organisms similar to bacteria, but they have many biological similarities to the nuclei-possessing eukaryotes that comprise multicellular organisms like humans and trees. Many archaea can thrive in extreme environments such as geysers, very salty lakes and sulfureous deep sea vents. Archaea are of particular interest to Chuck and his team because evidence suggests they are the primary methane producers.

During their March field expedition, the research team also measured greenhouse gas emissions from their various field sites. With most of the lake frozen, they didn't expect to measure much methane release. However, at a bore hole site located at the lake rim, they measured methane concentrations of 500-800 parts per million, which is roughly 400 times the normal atmospheric level of methane.

Using Sandia equipment, the team collected gas from this methane "chimney" and is working with scientists at the University of Colorado, Boulder to determine how old and how deep the carbon being converted into methane by microbes is, Chuck said.

The Sandia team is currently conducting laboratory experiments to study microbial populations found in the methane chimney to look for other gases indicative of microbial methane metabolism, Jenna said.

"We believe that we have underestimated the amount of methane release during winter and early spring and that there are likely many more methane chimneys than anyone has considered," Chuck said. "It's a scary thought, imagining hundreds of chimneys pumping out methane at remote Alaska sites. We don't know how much is really occurring, and that contributes to the uncertainty in our climate models."

Growing Arctic microbes

Jenna and Bryce are processing lakebed soil samples and dividing them into temperature- and moisture-controlled bioreactors.

COOL COLLABORATION — The team from left to right, Jenna Schambach, Sandia technologist; Nicholas Hasson, University of Alaska, Fairbanks graduate research assistant; Tess Hogancamp, Sandia postdoc; Bryce Ricken, Sandia technologist; Chuck Smallwood, Sandia bioengineer and project lead; and André Pellerin, University of Quebec in Rimouski professor pose with a core of Arctic lakebed soil on a microbe sampling trip in Alaska. Greater understanding of the microbes that produce greenhouse gases in thawing permafrost could improve climate modeling and prediction.

Photo courtesy of Chuck Smallwood

These containers can simulate what is happening in the thawing-permafrost lake system in the lab, Chuck said.

The researchers will sequence DNA from the samples to identify the types of microorganisms present in different layers of the lakebed before being grown in the bioreactors. They will also use similar sequencing approaches to track how microbe populations change over time during temperature and nutrient changes. The goal of these experiments is to connect microbes to the release of methane and other volatile gases.

"As we do these evolutions in controlled bioreactors, we will be sampling every so often to characterize how the microbe populations change over time," Jenna said. "The questions we're trying to answer: Who is in these incubations and when are they becoming prevalent in the community? We'll also be doing microbiology experiments to isolate strains of these very unusual organisms of interest."

The team will also be measuring what particular microbes are doing in the community by examining the RNA present. This will connect each microbe with an activity and perhaps even suggest which microbes are chiefly responsible for producing methane and their allies, the microbes that provide vitamins or other indirect assistance to the methane producers, Chuck said.

Detecting digestion gases

From the bouquet of a fine wine to the musk of aging compost, the activities of single-celled organisms produce distinct scents caused by a complex mix of gases. Philip Miller, a Sandia biological engineer, is spearheading the analysis of the gas samples collected on the trip to try to tease apart specific gases tied to specific biological activities in thawing permafrost.

During the trip, Chuck's team collected gas samples in small adsorption tubes. Philip compared these tubes to chemical sponges, able to "suck up" a lot of interesting gases without taking up a lot of space. Like the lakebed samples, these tubes were also frozen and shipped from Alaska to New Mexico. Now, Philip is beginning to see what kinds of gases they collected using an advanced piece of equipment called a comprehensive two-dimensional gas chromatograph with mass spectrometry.

"The name of the game for biomarker hunting of volatile compounds is separation," Philip said. "The second gas chromatography column allows for better separation of gases that have similar chemical backgrounds. We're able to see more, and it becomes easier to identify gases of interest. It's a starting point on understanding if we can use a similar tool to monitor a fragile ecosystem over a long period of time."

Philip will use the same advanced system to analyze the gases produced in real-time from the microbes grown in the bioreactors.

The goal for the team is to identify gases that are markers for important biological activity or the presence of important microbes. By the end of the three-year project, they hope to have the information needed to design a portable detector that looks for those specific gases in the thawing Arctic, improving scientists' ability to monitor the rapidly changing environment, Chuck said.

"I feel like this type of research to define how living organisms and climate impact each other is really taking off," Chuck said. "People are finally paying attention not just to what is happening above ground but how things are changing underneath our feet. For a long time, scientists only viewed soils as a source of carbon, but now we've realized that soils can produce or remove greenhouse gases. We are working with computational modelers such as Umakant Mishra at Sandia to ultimately model how soil microbes are contributing to greenhouse gas emissions to reduce the uncertainties in our climate change predictions."

This work is funded by Sandia's Laboratory Directed Research and Development program.

Mileposts

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Quantum inertial sensor

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In a major milestone toward realizing their vision, the team has successfully built a cold-atom interferometer, a core component of quantum sensors, designed to be much smaller and tougher than typical lab setups. The team describes their prototype in the academic journal Nature Communications, showing how to integrate several normally separated components into a single monolithic structure. In doing so, they reduced the key components of a system that existed on a large optical table down to a sturdy package roughly the size of a shoebox.

"Very high sensitivity has been demonstrated in the lab, but the practical matters are, for real-world application, that people need to shrink down the size, weight and power, and then overcome various issues in a dynamic environment," Jongmin said.

The paper also describes a roadmap for further miniaturizing the system using technologies under development.

The prototype, funded by Sandia's Laboratory Directed Research and Development program, demonstrates significant strides toward moving advanced navigation tech out of the lab and into vehicles on the ground, underground, in the air and even in space.

Ultrasensitive measurements drive navigational power

As a jet does a barrel roll through the sky, current onboard navigation tech can measure the aircraft's tilts and turns and accelerations to calculate its position without GPS, for a time. Small measurement errors gradually push a vehicle off course unless it periodically syncs with the satellites, Jongmin said.

Quantum sensing would operate in the same way, but the much better accuracy would mean onboard navigation wouldn't need to cross-check its calculations as often, reducing reliance on satellite systems.

Roger Ding, a postdoctoral researcher who worked on the project, said, "In principle, there are no manufacturing variations and calibrations," compared to conventional sensors that can change over time and need to be recalibrated.

Aaron Ison, the lead engineer on the project, said to prepare the atom interferometer for a dynamic environment, he and his team used materials proven in extreme environments. Additionally, parts that are normally separate and freestanding were integrated together and fixed in place or were built with manual lockout mechanisms.

"A monolithic structure having as few bolted interfaces as possible was key to creating a more rugged atom interferometer structure," Aaron said.

Furthermore, the team used industry-standard calculations called finite element analysis to predict that any deformation of the system in conventional environments would fall within required allowances. Sandia has not conducted mechanical stress tests or field tests on the new design, so further research is needed to measure the device's strength.

"The overall small, compact design naturally leads towards a stiffer more robust structure," Aaron said.

Photonics light the way to a more miniaturized system

Most modern atom interferometry experiments use a system of lasers mounted to a large optical table for stability reasons, Roger said. Sandia's device is comparatively compact, but the team has already come up with further design improvements to make the quantum sensors much smaller using integrated photonic technologies.

"There are tens to hundreds of elements that can be placed on a chip smaller than a penny," said Peter Schwindt, the principal investigator on the project and an expert in quantum sensing.

Photonic devices, such as a laser or optical fiber, use light to perform useful work and integrated devices include many different elements. Photonics are used widely in telecommunications, and ongoing research is making them smaller and more versatile.

With further improvements, Peter thinks the space an interferometer needs could be as little as a few liters. His dream is to make one the size of a soda can.

In their paper, the Sandia team outlines a future design in which most of their laser setup is replaced by a single photonic integrated circuit, about eight millimeters on each side. Integrating the optical components into a circuit would not only make an atom interferometer smaller, it would also make it more rugged by fixing the components in place.

While the team can't do this yet, many of the photonic technologies they need are currently in development at Sandia.

"This is a viable path to highly miniaturized systems," Roger said.

Meanwhile, Jongmin said integrated photonic circuits would likely lower costs and improve scalability for future manufacturing.

"Sandia has shown an ambitious vision for the future of quantum sensing in navigation," Jongmin said.

Answering the call

Sandians support national security mission

In support of the Nuclear Deterrence Modernization Efforts Rally Cry, Lab News continues to highlight employees and the ways that they contribute to Sandia's national security mission. Read more profiles from previous editions.

Dave Robinson

Chemist and materials scientist
17 years at Sandia

Dave is part of a team that studies hydrogen, the fuel of the stars, and — for a small but growing number of people — their cars.

Photo by Randy Wong

"Our team studies the basics of how hydrogen interacts with other materials and how it could be used to address global challenges," Dave said. The research calls for broad collaborations and Sandia works closely with Savannah River National Laboratory and Pacific Northwest National Laboratory.

"Much of the current enthusiasm in our lab comes from the discovery of new alloys that absorb and release hydrogen in ways that are readily tailored to specific goals," Dave said. "In recent weeks, we have been setting up new experiments that will allow us to verify the properties of the alloys at a pace closer to the pace at which they can be proposed and prepared.

"We have always been a nimble group that is ready to tackle new opportunities, and we have heard the call from the Labs director," he said. "We have skills and ideas to offer and look forward to learning more about how we can contribute."

— Mattie Hensley

Lauren Shea Rohwer

Materials scientist
25 years at Sandia

Lauren studied materials science because the discipline spans synthesis, processing and characterization and overlaps with chemistry and physics. Her work at Sandia's Microsystems Engineering, Science and Applications center allows her to apply her materials background to focus on packaged devices for nuclear deterrence and satellite applications.

Photo by Craig Fritz

"Solutions to these problems might involve introducing a new material to improve the reliability of a device and performing experiments to ensure it will function after accelerated aging tests," she said. "Or in some cases, a material might have the right properties for a particular application but can't be implemented using conventional methods. So, a new method must be developed."

After 25 years at Sandia, national security work continues to interest Lauren because of the added challenge to guarantee products operate dependably for decades. She's proud to work with a team of enthusiastic and motivated colleagues who possess the complementary skills needed to meet that challenge.

"Finding solutions to such problems is rewarding especially if it helps more than one project succeed," she said. "It's satisfying to contribute to programs that help advance the nation's technological capabilities needed to adapt to new and existing national security threats."

— Jill Janov-Kelly

Jim Mackanic

System surety engineering lead
8 years at Sandia

Jim feels it was "providential" that he came to Sandia. Working for a Silicon Valley company late in his career, he

was looking for new opportunities when his wife mentioned talking with a friend whose husband worked at Sandia. He did some research and applied.

Photo by Randy Wong

The focus of Jim's job is to ensure that the product and program he supports meets both functional and programmatic requirements from the DOD and the NNSA.

"It is pretty obvious that our products are critical for maintaining national security through having an effective nuclear deterrence, so helping to ensure the system and component engineers understand our requirements and that the design and product meets those requirements directly contributes to our national security," he said.

Jim enjoys his job, the people he works with and coming to work each day, he said. "Sandia is a place where experience actually is appreciated. At Sandia, people are really valued and not looked upon as a resource to be applied to an objective."

— Kim Bustamente

Jenny Gilbride

Senior scientist of systems analysis and engineering
39 years at Sandia

When Jenny joined Sandia from Texas A&M University, she had "no idea what I would be doing. I knew it was related to nuclear weapon programs."

Photo by Craig Fritz

Nearly four decades later, she has contributed to nuclear weapon development, evaluation and surveillance, national missile defense and humanitarian demining efforts with Russia. She has supported launches out of Kauai, Hawaii; Kodiak, Alaska; and Vandenberg Air Force Base in California, worked on unmanned combat vehicles with DARPA and DOD, and completed an Intergovernmental Personnel Act assignment with the Navy Strategic Systems Program in Washington, D.C.

It is rewarding "to complete a deliverable — accomplish something that makes a difference, has an impact … to do it as a team."

As W88-0 weapon systems lead, she implemented stockpile-to-target shock and vibration preconditioning of surveillance units that were to undergo tests. Today, this is standard testing.

She also pushed for substantial modeling and simulation efforts on the legacy W88-0 development program, which became the first system with validated structural models to support follow-on studies. Today, she is a systems analyst.

"We look at the potential impacts of newer technologies and alternative stockpiles," Jenny said. "We ask, what's different today and how should we be adapting to the future?"

— J.C. Ross

Curtis Peters

Nuclear engineer
8 years at Sandia

Curtis works in Sandia's Advanced Nuclear Concepts group and conducts radiation transport modeling of electronic components and systems that are tested in nuclear facilities across the country.

Photo by Craig Fritz

"Sandia is responsible for designing, testing and verifying electronic components associated with the stockpile. So, it's our responsibility to make sure it operates as expected in radiation environments," Curtis said.

Sandia offers employees a chance to be involved in exceptional research and development that directly contributes to mission work, he said.

"Working here provides an opportunity to do interesting work that only happens at a very limited number of facilities," Curtis said. "I get to work with people doing various types of experiments not done elsewhere that utilizes reactor facilities all across the country."

— Sarah Johnson

Cultivating safety culture at Sandia

National Safety Council names Christopher Quinn-Vawter a Rising Star of Safety, Class of 2022

SAFETY SUCCESS — Sandia industrial hygienist Christopher Quinn-Vawter was recently recognized as a Rising Star of Safety by the National Safety Council for demonstrating leadership and fostering a strong culture of safety through several initiatives at the Labs. **Photo by Craig Fritz**

By **Luke Frank**

Safety isn't just an idea, initiative or program. Safety is a culture, according to Christopher Quinn-Vawter, a Sandia industrial hygienist in the Environment, Safety & Health division and National Safety Council Rising Star of Safety, Class of 2022.

Chris was recently recognized by the council for his demonstrated leadership, safety initiative success, safety culture engagement and personal ethics in promoting safety in Sandia business operations.

"A safety program checks a regulatory box spelling out the policies and procedures to comply with regulations or help guide workers in basic requirements," Chris said. "A safety culture is about workers taking an active role in their safety and understanding existing or emerging hazards associated with their activities. It's an important distinction, and our work at Sandia incorporates both."

Chris demonstrated his leadership during a 2021 national security project to recover test components that would provide valuable forensic information. There were numerous potential safety hazards associated with the recovery, and Chris led the team's assessment of site conditions following the test. He developed mitigation measures for a wide range of chemical, respiratory and other operational hazards and implemented controls to ensure the team's safety.

Chris also showed leadership while guiding a successful safety initiative pilot. As the industrial hygiene lead for the Smart Labs initiative to identify efficiencies for local exhaust ventilation systems, Chris implemented the Laboratory Ventilation Risk Assessment tool to find hazards and associated risk in lab spaces, including 91 laboratory fume

hoods.

"The new Smart Labs initiative will enable Sandia to design and manage our laboratory ventilation systems much more efficiently and effectively," said Chris. "It's a leadership-supported project that will significantly improve safety for hundreds of Sandia employees and contractors."

Through this initiative, Chris and his team identified in a single building several fume hoods for replacement and numerous unused ventilation systems that could be capped to reduce system flow. "We were able to optimize ventilation controls that enhance safety for workers during daily operations while saving energy," he said. "We hope to expand this process to the rest of Sandia's campus soon."

Chris' expertise in exhaust ventilation systems enables him to provide his peers with technical support in evaluating old systems and identifying design criteria for new systems. Consequently, he has established close relationships with the facility engineering teams he supports and continues to build a culture of trust throughout Sandia.

"Honestly, being nominated for this award by my ES&H peers means as much to me as the award itself," Chris said. "My nomination signifies Sandia's awareness of and commitment to workforce and personal safety and its support of those working on our programs' front lines."

Since 2010, the National Safety Council has honored the next generation of safety professionals through the Rising Stars of Safety award. Rising Stars are under age 40, provide safety leadership in their organization and are dedicated to continuous improvement in safety.

"These 39 women and men hail from 31 states and eight countries, making this year's class of Rising Stars NSC's most diverse yet," said Lorraine M. Martin, National Safety Council president and CEO. "Each has demonstrated enthusiasm, skills and leadership that will undoubtedly inspire other safety leaders and colleagues. They exhibit a commitment to doing their part in ensuring people live their best lives, free of preventable injury and death."

Spooky STEM

PUMPKIN ERUPTION — Volunteers with Sandia Women's Action Network visited students at the Manzano Mesa Multigenerational Center to promote interest in STEM by leading autumnal activities. ES&H Coordinator Kara Komula, left, and systems engineer Joe Mohagheghi made erupting pumpkin volcanoes with the students. Sandia has planned STEM activities at the center every Wednesday afternoon through May. **Photo by Debra Menke**