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Rock Stars

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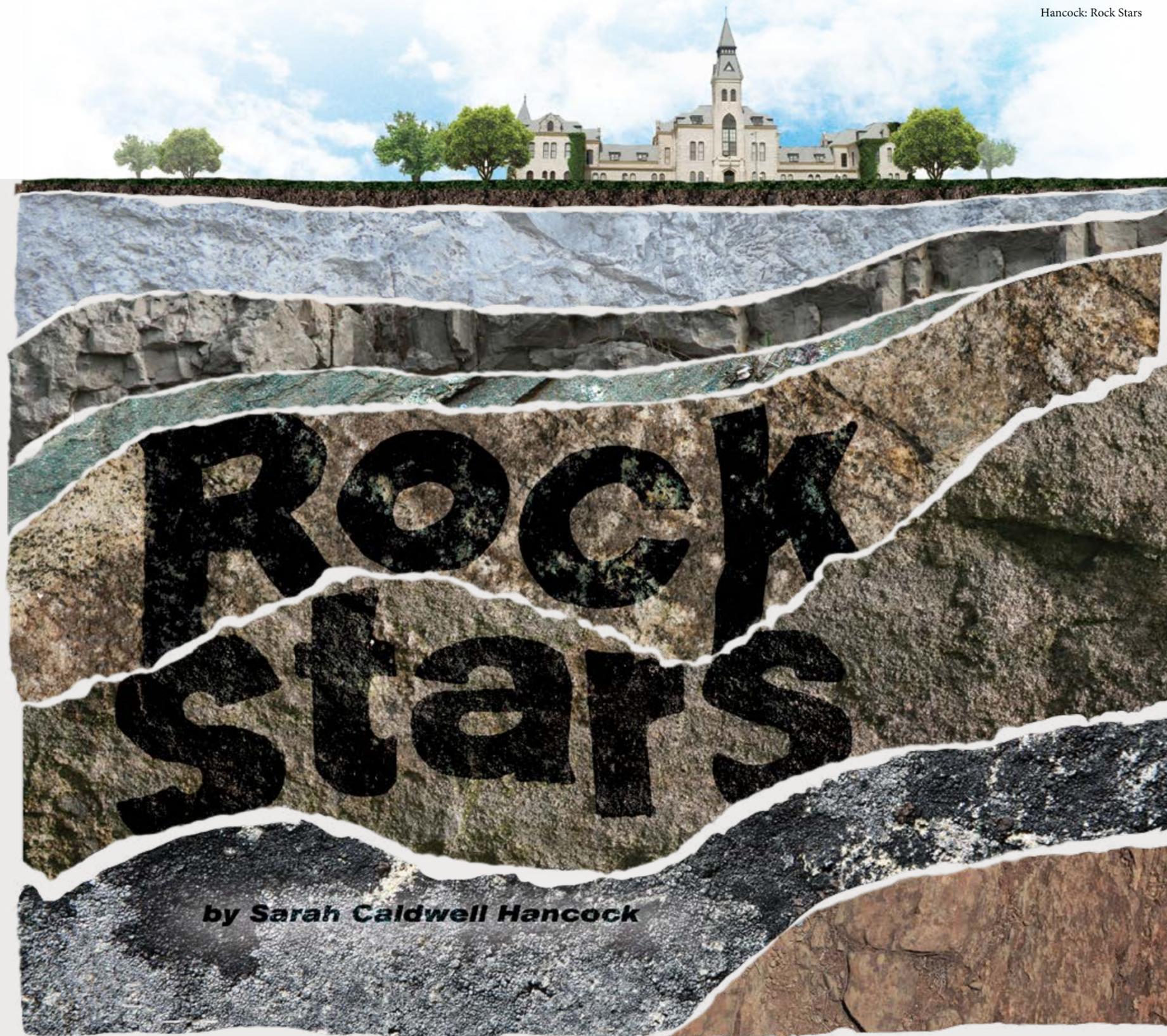


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Kansas State University geoscientists explore interrelated processes to protect resources and human health

Humans have not had a long time, geologically speaking, to advance understanding of the earth and its processes. We've had even less time to connect knowledge in different disciplines.

Geosciences researchers at Kansas State University are making those connections in everything from the formation of volcanoes and mineral resources to finding the "control knobs" for natural processes that cause sediments to release metals in water. Their work ultimately helps protect precious resources to boost food, energy and water security as well as human health.

The lost arc

If you were a kid who hoarded rocks and minerals, you can probably relate to Matt Brueseke's specialty in petrology, or how rocks form.

Brueseke's particular interest is in igneous petrology, or rocks that solidify from lava or magma. Samples of rocks that came from magma can shed light on the relationships between volcanoes and the movement of large sections of the earth's crust over the underlying mantle, also known as plate tectonics. Studying material volcanoes churned out in the past helps us understand hazards like Yellowstone and other volcanically and seismically active areas. The best place to do this is where there's a plate boundary.

Alaska fills the bill; specifically, Wrangell-St. Elias National Park and Preserve's 13.2 million acres encompass a huge, complex arc of volcanoes.

"We hardly know anything about them," said Brueseke, an associate professor of geology at K-State. "We're calling it the lost arc."

One reason we don't know much about the area is that it's not an easy place to take samples. Everything is remote: so much so that Brueseke and other members of his National Science Foundation-funded team have to travel in Piper Super Cubs. The light planes can land in 30 feet



Matt Brueseke



when necessary, which is handy in a place where paved runways are out of the question. The planes each carry supplies for one or two people for five days in bear containers and buckets with lids. Weight limits are strict.

Conditions and logistics are challenging. Researchers hike up surrounding cliffs and through muskeg, the local term for bogland — sometimes for many miles — and collect lava samples. Helmets are required because terrain can be steep and researchers must guard against falling rock. Alaskan summers are damp, with temperatures in the 60s to 70s in the daytime and the 40s at night. As researchers empty their bear containers of food, they fill them with rocks. The next site's supplies are already packed and ready, so when the team has collected enough samples at one site, the plane comes and takes everyone to another spot, a process that requires four or five flights. If the wind is blowing or the cloud base is too low, the Super Cubs can't fly, so schedules and supplies may have to stretch and team members can be stuck in their tents.

Brueseke said the fieldwork is more intense than he's ever done, but the fist-sized samples he and his team haul out of the park yield a wealth of information with global implications. Back at home, the researchers look at thin slices of the rocks under a microscope and pulverize some into a powder to send to labs that determine element and isotope concentrations that indicate what melted to form the rock. Radiometric dating helps researchers piece together a history of the mysterious volcanic field: frequency and types of eruptions, relative ages of different volcanoes, and the relationship between volcano formation and plate movements. All of this helps advance understanding of how the volcanoes developed, when eruptions occurred and how dangerous those eruptions were. Many trans-Pacific flights go near and over the Wrangell Mountains, and



Wrangell arc-derived ash has been identified in Europe. When these volcanoes erupt again, they will affect people well beyond Alaska and the Yukon because of the significant hazard they pose to worldwide air traffic.

Another major project of Brueseke's is applying this research to the process of gold and silver mineralization. "You can apply the same skills and techniques that determine why the magmas are there to determine why the ores are there and how they are related to plate tectonics," he said.

This mineralization work in Nevada and Idaho differs in obvious ways from his project in Alaska — he's not volcano hunting, and the scenery, although striking, isn't as photo-worthy — but he says both projects have great benefits to Kansas State University students.

"It opens up those research experiences, whether they are for undergrads or grad students," he said. "It allows me to bring modern, advanced techniques into the classroom. I teach introductory geology, mineralogy, petrology and economic geology. I can bring in firsthand knowledge of how we study mineral deposits and plate tectonics. That happens at the undergraduate level and the graduate level, in classes for both geology majors and nonmajors."

Brueseke said that geoscientists with training in solid earth processes are in demand.

"As a society, it's important to understand minerals. No matter where you live, we use resources," Brueseke said.

Protecting resources with microbial 'control knobs'

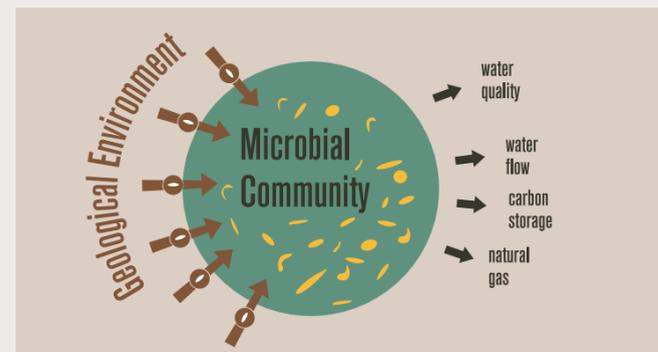
Protecting those resources is an ongoing task for two other Kansas State University geologists. Their work operates at disciplinary boundaries, uses the latest techniques, and opens surprising avenues between geology and food, energy and water security.

Matthew Kirk, assistant professor of geology, studies microorganisms in detail.

"Geomicrobiology was virtually unheard of 30 years ago," Kirk said, "and so we have only recently begun to appreciate the role that microorganisms play in driving chemistry in geological environments."



Matthew Kirk



Kirk studies aquifers, or permeable underground layers of rock or sediment that are saturated with water. Aquifers are populated with microorganisms that drive reactions and affect water quality, and he works to understand the influences on microbes.

"Understanding environmental controls on microbial populations helps us understand how microbial reactions are distributed and how they affect water resources. We can also use the 'control knobs' on microbial populations to adjust quality in both natural and engineered systems," Kirk said.

Like us, many microorganisms eat organic matter and essentially breathe oxygen, but they can eat and breathe many other compounds as well. When they eat and breathe these compounds in aquifers, it changes the chemistry of the water. Microbes that breathe iron and sulfate can make pyrite particles, or fool's gold, for instance, or release trace elements like arsenic. Instead of looking at specific contaminants, Kirk said an overall understanding of the microbial community may lead to better and less expensive ways of enhancing water quality.

"You may be able to do something simple to perturb the microbial community in such a way that a contaminant is removed from the water," he said.

Saugata Datta, associate professor of geology, helps Kirk determine how microbial populations release sediments in water and conducts other water-related research. He looks for toxic trace elements such as arsenic and heavy metals such as tungsten in drinking



Saugata Datta

waters around the world. Water is essential for everyone and needs to be protected, so his collaborations with U.S. and international colleagues explore how water is affected in places such as Bangladesh, India, Argentina, Tanzania and Cambodia. Another project explores plant uptake of heavy metals and assesses effects on the food supply. In the Mississippi Delta, for example, sediment contains arsenic because pesticides used for ages in cotton-growing regions contained the poison.

"The problem doesn't really happen if the arsenic is retained in the soil, but when it gets mobilized and goes into the water, then it goes into the plants because you're irrigating the lands with the same contaminated water," Datta said.

What happens when we boil the rice grown in this area? How much arsenic does the grain absorb, and how much does it pass on to us? Datta is measuring arsenic uptake with the latest synchrotron radiation techniques and using facilities in national laboratories across the U.S.

Datta's work on what contaminants do to humans is an emerging and highly interdisciplinary field known as medical geology. He notes that 80 to 85 percent of the

problems are from natural rather than human-caused pollution. Fluorides in water are another example, as is manganese, which can cause symptoms that resemble Parkinson's disease. The World Health Organization currently has no maximum contaminant level, or MCL, for manganese in water, but Datta advocates stipulating a safe limit. Datta is working with atmospheric scientists to combine findings with soil science and hydrology to understand the risks of manganese and how to keep people safe.

Contaminants aren't limited to water, and neither is Datta's research. He also considers the dangers of inhaling atmospheric particles that contain fractions of metals. "Metals have three possible primary pathways in the environment: water, soil and air," Datta said. Both the National Science Foundation and the U.S. Environmental Protection Agency support his work.

Geoscience researchers are well positioned to help solve pressing problems, Datta said.

"I'm in a field that can work with many other fields," he said. "Think of the earth where you are living — so many different interrelated processes are going on around you. How are you going to offer a solution? You can gain that knowledge from geosciences."

"I have water and food security in my heart," Datta said. "Nothing can be bigger than that right now."



The future of energy extraction

As Kansas State University researchers apply their work in fields outside the conventional boundaries of geology, they also work to see traditional areas through the lens of new discoveries. One such field is the extraction of fossil fuels, where Kirk's research into microbial populations may have huge implications.

Microbes are instrumental in the formation of natural gas. Because natural gas is the cleanest fossil fuel and is inexpensive, it's overtaking coal as our main source of electricity. Kirk is exploring the Cherokee Basin in southeast Kansas, where relatively shallow coal beds are helping him study how microbes make methane, the main constituent of natural gas. If we understand how to stimulate naturally occurring microbes so they make more methane, we could convert crude oil in depleted oil reserves — which still contain as much as 60 percent of their oil but can't be pumped — into recoverable fuel.

Research into microbial activities in water and fossil fuels are both important to Kansas.

"What's agriculture going to look like in Kansas in 20 years when the High Plains Aquifer is getting closer and closer to the end of its useful lifetime? It's a huge factor in where we go economically," Kirk said.

Kirk believes his research could help the declining oil and gas industry in Kansas, too. Microbial methanogenesis may be the future of energy extraction from subsurface hydrocarbon reservoirs.

"You could move into those depleted oil reservoirs and continue to extract energy," he said.