EXPLORERS OF THE UNDERGROUND

Earth scientists **dig** *into rocks and soil to discover treasures of planet Earth.*

By Lisa Westberg Peters

Photography by Selma Fernandez Richter

Earth's crust feels solid and still beneath our feet, but under the surface there is a shifting jigsaw puzzle of sections called *tectonic plates.* Fossils show that the birds we see today evolved from dinosaurs. Minnesota has some of the oldest rocks in the world. They're about 3.6 billion years old. We know these startling facts because earth scientists asked questions and searched for answers.

Geologists study the Earth, the forces that act on it, and the history of life. They often see the world differently than others do. To a geologist, the North Shore of Lake Superior isn't just a beautiful place. The

Clockwise from top left: Sandstone cliffs, pumps that bring up water from wells, and rock samples from deep underground are all part of the work of Minnesota geologists.

lake marks the spot where the North American continent almost split apart 1.1 billion years ago. And the smooth slabs of bedrock aren't just a great place to sit. The rocks were once molten lava, which rose from deep inside the Earth and flowed across the land.

Earth scientists investigate questions all over the world. While working outdoors, a geologist might have to huddle inside a tent on cold, windy days or crawl through limestone caves. In an office, a geologist might examine rocks with a microscope for evidence of gold. Some geologists work for companies that search for valuable minerals (particles within rocks) or oil (used to make gasoline, plastics, or other products). Others help cities clean up water and soil polluted by spills of gasoline or other toxic substances. Still others do government or university research on ancient sea life, volcanoes, or earthquakes.

This story looks at the work of three earth scientists in Minnesota.

Heather ARENDS

Hit or Sift? "I used to be a rockhound, but for the longest time, I thought I wanted to go into archaeology," says Heather Arends, a geologist with the Department of Natural Resources. Archeologists go on digs to look for evidence of early human settlements. Heather's career ideas changed when she went to the University of Minnesota–Morris and met a great geology professor. She enjoyed piling into vans with her geology classmates and traveling to different places to learn the stories rocks have to tell. They studied in the Black Hills of South Dakota, the glaciers of Iceland, and the Rocky Mountains of Canada. On field trips, they would pass by archeologists sifting carefully through soil for arrowheads, pottery, and other things. "We would go up to a rock and just whack it off," says Heather. "There are whackers. And there are sifters." Heather decided she was a whacker.

Digging the Pits. As a student, Heather visited gravel pits, where people dig for gravel and sand left by glaciers. Often called rivers of ice, glaciers covered most of Minnesota thousands of years ago. As they moved slowly across the land, they scraped off rocks and crushed them into smaller pieces. When the glaciers finally melted and retreated to the north, they left behind deposits of gravel, sand, and other sediments.

Near Minnehaha Falls and the Mississippi River in Minneapolis, geologist Heather Arends stands next to a cliff made of St. Peter sandstone. She says this place was a sandy beach on a tropical ocean 500 million years ago.

The DNR hired Heather to map those deposits. Rocks and sand are used to make concrete for sidewalks. A highway department might need gravel to spread on roads. Heather explains an area's geology to people who might use sand or gravel,

"so when people read our maps, it's not in another language. I like bringing science to people in a way that's understandable."

The DNR has rules to help protect the land and water near many mining operations. Heather has traveled all over Minnesota to talk with county leaders about sand and gravel mining. They discuss the best ways to manage sand and gravel resources now and in the future. They also discuss how to *reclaim,* or restore, the land after mining. For example, a gravel mining company will reshape the ground dug up by mining. A company might plant new trees or grasses to cover the soil and help keep it in place.

Today some companies are using silica sand to help drill for oil and gas across the country. Southeastern Minnesota has deposits of silica sand. Silica sand is made up mostly of grains of quartz, a common mineral prized for its hardness. About 500 million years ago winds blew huge volumes of quartz grains across the land surface, shaping them into round sand grains. The sand was then carried by rivers and wind to the edge of a shallow sea that flooded Minnesota, where it formed beaches along the shoreline. These beach deposits are the material that is mined as silica sand today.

Now Heather is writing the new state rules for reclaiming silica mines. Writing can be hard, but it's "part of being a scientist," she says. "Like anything else, it becomes easier with practice."

Dave DAHL

Outdoor Adventures. Ever since he was a kid, Dave Dahl has loved maps. In third grade he studied the map of Minnesota and memorized all 87 counties. He also enjoyed hunting, fishing, and visiting state parks with his family.

"I didn't dream I'd be a geologist. I thought I'd be a forester," Dave says.

But as a college student, he took a few geology classes and realized that studying earth science was a great way to go camping in faraway places. He studied the sea coast of Florida, the mountains of Montana, and volcanoes in west Texas. He learned to recognize the color, hardness, and shapes of minerals. He also became good at imagining how the land

With a magnifying lens, geologist Dave Dahl studies fine details of minerals. This rock sample "tells one sentence in the book of Minnesota's history," he says.

At the DNR's rock library in Hibbing, Dave Dahl pulls out a box of rock samples. Instead of books, the stacks of this library hold thousands of samples called drill cores. Cores are collected by drilling deeply buried bedrock.

might have looked in the past. Being able to recognize minerals and visualize past landscapes are useful skills for geologists, he says.

Treasure-Hunting Maps. Dave is a geologist with DNR Lands and Minerals in Hibbing. He uses a tool known as a Geographic Information System, or GIS, to make digital maps. He helps mineral explorers and land managers use the maps. For example, he made a map to help discover if Minnesota has gold deposits. Other maps point toward deposits of minerals containing copper and nickel. Copper is used in electric wiring. Nickel is used in making stainless steel. Cell phones, computers, and other electronic devices also contain copper and nickel.

Computer-generated maps help Dave and other mineral experts decide where mining companies might explore for valuable minerals. The state of Minnesota owns the mineral rights on 3.5 million acres called school trust lands. When mining companies take minerals such as iron ore from school trust lands, they pay millions of dollars to a fund (like a bank account) for Minnesota public schools.

Heavy Rock Library. An unusual library helps Dave do his job. It holds a collection

Besides computer-based maps, geologists today study historical maps. In the 1950s, geologists used these maps to help find the location of iron-bearing rocks on the Cuyuna Iron Range in central Minnesota.

of drill cores—heavy cylinders of rock. Earth scientists drill down in bedrock and pull out these samples of rock. Geologists study drill cores to learn more about geologic history and how the landscape has changed through time.

The library's three buildings contain 300,000 boxes of rock cores, from granite to sandstone. Each box weighs about 30 pounds, so the whole collection weighs 9 million pounds. It might be Minnesota's heaviest library.

Dave meets with mineral explorers who come from around the world to study these rock samples because their countries have similar rock formations. The cores have led mineral explorers to discover several new mineral deposits in northeastern Minnesota, Dave says.

Dave tells the story of two curious teachers who came to the library searching for evidence of a giant meteor that hit the Earth about 1.8 billion years ago. The teachers knew that a big meteor collision would throw a huge cloud of broken rock and dust into the air. They also knew the rock debris would settle on the Earth like a blanket. They looked for this blanket, or layer, of broken rock in northeastern Minnesota. At the drill-core library, they found evidence of the layer. The discovery added a new chapter to our state's geologic history.

Mindy ERICKSON

Hook and Line. You never know what tools you might need to do scientific research. You might need fishing line and a hook, as Mindy Erickson discovered. As a college student, she had a summer job collecting water samples from wells. Mindy would attach a rope to a clear plastic, tube-like tool called a bailer. Then she would lower the bailer into a well, a deep hole drilled in the ground to reach groundwater. Groundwater is water held in the soil and in the tiny spaces in rock underground.

The wells were near a landfill, where solid waste (garbage) is buried between layers of soil. The landfill operator must be careful to keep harmful waste chemicals from seeping into the ground and polluting groundwater. Mindy's water samples would show if groundwater was polluted.

Mindy collected so many water samples that the rope finally untied, and the bailer "dropped from sight back into the well," she says. Luckily, the landfill operator had a fishing line and a hook in his truck. Together they fished the tool out of the well. From then on, Mindy carried fishing gear on her water sampling trips.

Today Mindy works for the United States Geological Survey as a hydrologist. She studies water above and below ground.

Mindy didn't always know she wanted to be a scientist. She went to college to "do something environmental" and took a class to learn about groundwater. She also learned about science jobs like environmental chemist, engineer, geologist, and hydrologist. She earned a degree in geological engineering. Later she studied arsenic, a toxic element, in groundwater. She enjoyed the work so much, she decided to go back to school so she could design her own research projects.

For the past 20 years, she has studied the movement of arsenic and other chemicals in our state's groundwater. Arsenic is tasteless and odorless and occurs naturally in Minnesota's soil and rocks. But it can cause cancer and other health problems for people who come in contact with it for a long time. Mindy's research has helped find places where groundwater contains too much arsenic to be safe to drink.

All city water supplies in the state are tested and, if necessary, treated for arsenic.

Teachers resources:

Teachers Guide: *www.mndnr.gov/young_naturalists*
Ask A Rock: *bit.ly/1NzCLlV*
Agate Hounds: *bit.ly/1kAnJG2*

Hydrologist Mindy Erickson collects water samples pumped from underground rock formations.

Mindy visits many people who live outside cities and have their own private wells. She talks to them about arsenic and treatment systems. And she speaks to well drillers about arsenic in underground layers of rock, sand, gravel, and clay. When people and businesses learn about the dangers of arsenic, Mindy says, they can find the safest ways or places to drill wells.

"I want to do something that makes a difference," Mindy says. "I've seen changes in people's choices when they have knowledge."

Most workdays, Mindy meets with her team of scientists to talk about research questions. She writes scientific papers and often takes time to help young scientists plan their careers.

Mindy's life isn't all science. She enjoys making clay bowls, cups, and other pots. Both art and science require creativity and a willingness to experiment and fail. "Be open," she says. "Try new things."