Petroleum engineering master's student Blessed Amoah examines the microstructure of rocks at the atomic level at Mewbourne College's Devon Energy Nano Imaging Laboratory. Amoah is using a scanning electron microscope so powerful that it can image items down to a sub-nanometer resolution – about 1/50,000th the width of the human hair or the length of 10 hydrogen atoms lined up side by side.

August 31, 2022

Geothermal Energy Research is a Win for OU and Oklahoma

The University of Oklahoma is pioneering new geothermal energy developments that leverage the state of Oklahoma's longstanding oil and gas expertise. This innovative research and development has the potential to bring new jobs to Oklahoma, diversify the economy, and leverage the skills of Oklahoma's oil and gas energy workforce, while also training the workforce of the future to ensure the state remains a leader in the nation's domestic energy production.

Geothermal energy uses the Earth's natural heat to create energy. There are two methods for gathering and using geothermal energy. Both involve tapping geothermal hotspots deep below the Earth's surface that contain water heated by the planet's core.

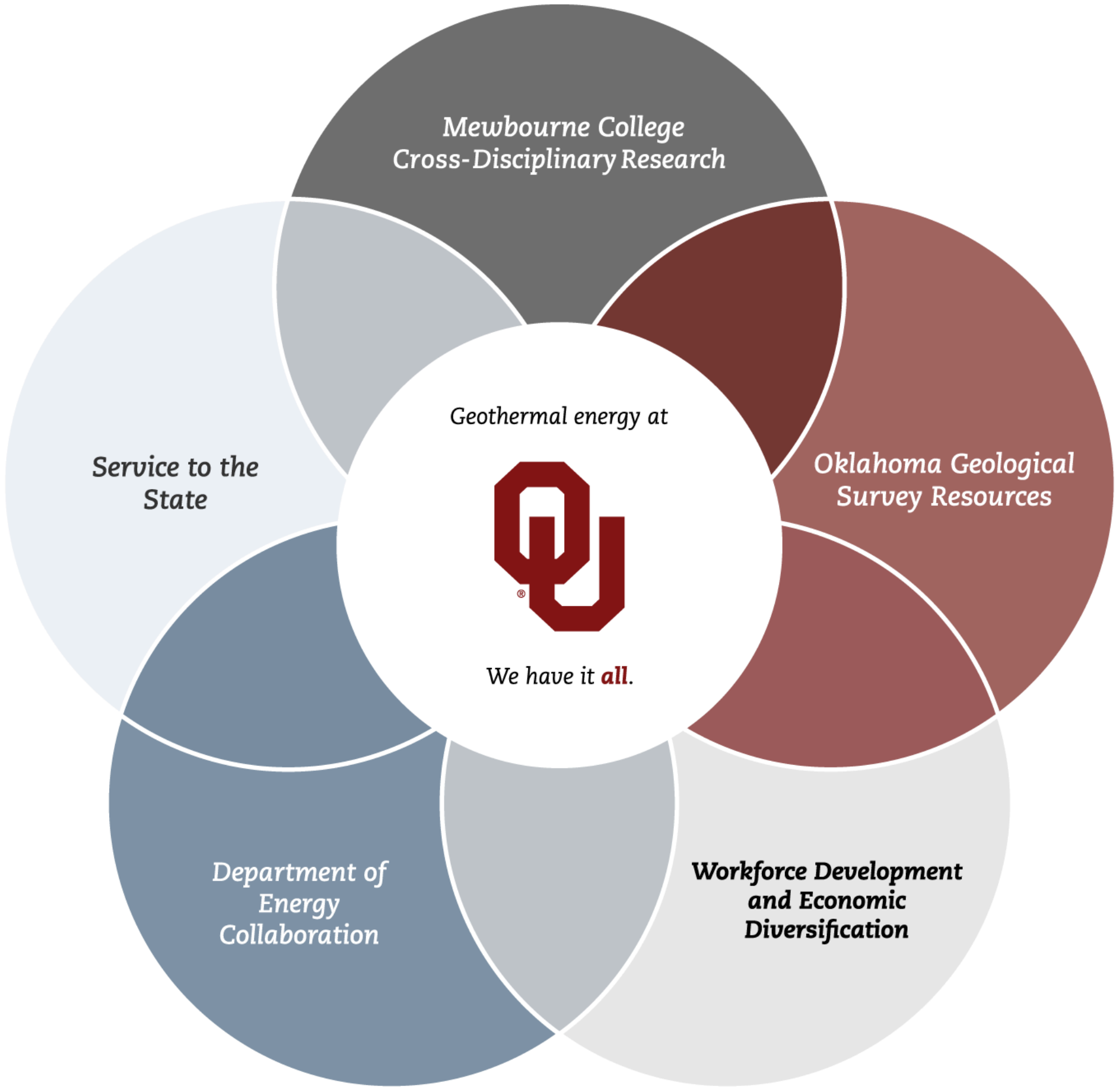
Engineers can harness steam to create energy and provide sustainable baseload power to the grid. They can also pipe hot water up from deep within the Earth and use it to heat buildings.

The U.S. is the largest producer of geothermal power in the world; however, a common misconception is that production from geothermal energy is only feasible in regions with the hottest geothermal activity, like Hawaii, California and Nevada.

OU researchers have not only disproved this misconception but have also identified Oklahoma as a prime location for geothermal power. A multi-disciplinary research team at OU is gaining momentum and providing a unique opportunity for researchers and Oklahomans alike.

"OU is an energy university; we believe geothermal is a key component of the future global energy mix and a source of future sustainable baseload power to the grid. Our top-ranked School of Petroleum Engineering and our world-class geological sciences expertise make OU a world leader in the research, development and application of geothermal energy," said Tomás Díaz de la Rubia, vice president for research and partnerships at the University of Oklahoma.

OU's Mewbourne College of Earth and Energy is the only college in the nation to bring together energy and geoscience disciplines. The college also houses the Oklahoma Geological Survey. Mandated in the Oklahoma constitution, OGS serves the state by investigating the state's land, water, mineral, and energy resources, and promoting the wise use of the state's natural resources.



OU: A Hotspot for Multi-Disciplinary Geothermal Research Activity

Mewbourne College of Earth and Energy researchers are approaching geothermal research from a variety of angles. Each research project provides a unique perspective, an individual piece of the puzzle, that will contribute to Oklahoma harnessing its geothermal advantage.

“Over the next decades, we expect that geothermal energy will become an increasingly important baseload energy source that will complement wind, solar and natural gas,” said Mewbourne School of Petroleum and Geological Engineering Director and Eberly Family Chair Runar Nygaard.

Another benefit of Oklahoma being a testbed for this innovative research is Oklahoma’s substantial geothermal potential in the form of deep sedimentary basins, and the benefit of a century of subsurface exploration.

“We are well poised to make an impact in geothermal energy by this confluence of geology and subsurface knowledge,” said Lynn Soreghan, director and Eberly Chair at the School of Geosciences.

Retired Oil Wells May be The Key to Oklahoma’s Geothermal Advantage

“Oklahoma can become the geothermal capital of the nation,” according to Mewbourne School of Petroleum and Geological Engineering Associate Professor Saeed Salehi. And Salehi believes retired oil wells are key.

“The largest risk and expense in geothermal energy is drilling the well. We’re eliminating it,” said Salehi.

Salehi and his team are set to become the first in the world to transition retired oil wells into geothermal wells, a project that has garnered national attention from the likes of *Vox* and *Forbes*. The four wells in Salehi’s research project are located in Tuttle, Okla., near two schools.

Associate Professor Saeed Salehi

The risk, cost and environmental impact of drilling geothermal wells becomes obsolete when utilizing retired fossil fuel assets. Though Oklahoma's geothermal temperatures are not as hot as those in traditional geothermal energy regions, the state's abundance of retired oil wells and their proximity to end users outweighs that perceived limitation.

"We are blessed with so many of these wells throughout the state. They are close to the schools, close to factories, close to farms. In Oklahoma, we do not need to invest in miles of pipelines to deliver energy to end users," Salehi said.

In Ahmad Ghassemi's Rock Mechanics Lab, rocks are put to a variety of tests to determine their characteristics. Ghassemi inserts a core sample into a machine that will simulate the pressure of rocks deep in the earth.

Stimulation May Increase Geothermal Energy Output while Decreasing Costs

Ahmad Ghassemi, the McCasland Chair and a professor of petroleum engineering at the Mewbourne School of Petroleum and Geological Engineering, is engaged in research funded by the U.S. Department of Energy and Coso Operating Company to use controlled stimulation to increase geothermal power production while simultaneously decreasing production costs.

Using advanced 3D modeling technology, Ghassemi and his team are studying the area around long-used geothermal wells at the U.S. Navy's Naval Air Weapons Station China Lake in eastern California. After extensive observation, modeling and computer simulation, they will create and monitor controlled fracture networks around the wells. They theorize the fracture networks will improve well output in a cost-effective manner.

"Ghassemi's innovative project in support of the Department of Energy has enormous potential to open up new avenues to extract geothermal energy from the earth's subsurface at low cost. Success in the development of this important clean energy technology will no doubt have significant, real-world impacts for Oklahoma, the nation and the world," said Díaz de la Rubia.

Safety Above and Below Ground

The processes of drilling petroleum and geothermal wells are similar. Mewbourne School of Petroleum and Geological Engineering professor and Mewbourne Chair in Petroleum Engineering Catalin Teodoriu is among the most respected drilling researchers in the world. By applying his expertise to geothermal engineering, OU is positioned to address concerns specific to geothermal wells.

Below ground, two common drilling issues are compounded: stability and heat. Several of Teodoriu's research projects address these factors.

"When drilling geothermal wells around the world, we often encounter hard rock. Drilling in these environments creates high vibrations, which in turn can cause instability below ground," said Teodoriu.

With the use of the largest drilling vibration simulator in the world, housed at OU, he is developing new computer algorithms to safely drill in these conditions. In addition to vibrations, Teodoriu has developed a unique, long-term cement repository that is yielding information on ways to improve the construction and utilization of such wells.

By their very nature, geothermal wells come into routine contact with extreme temperatures. Teodoriu is also developing a long-term, high-temperature testing facility for the components used in geothermal wells.

Above ground, Teodoriu's other area of expertise – human factors – holds unique applications to geothermal energy. Human factors is a field that combines engineering and psychology and seeks to identify and minimize the causes of accidents precipitated by human error.

"Drilling geothermal wells is challenging for the crew and equipment due to the high temperatures involved and the fact that current oil and gas safety protocols have not been fully adapted for high-temperature, high-pressure conditions," said Teodoriu.

Teodoriu developed Universal Drilling Language, an innovative training concept that teaches drillers and drilling crews how to communicate during the drilling process. Trained crews should be able to react decisively when faced with making fast, critical decisions. Teodoriu believes Universal Drilling Language will be especially valuable to new geothermal drilling crews because it will help improve safety awareness in geothermal wells.

Geochemistry Insights for Geothermal Energy

Megan Elwood Madden, Robert and Doris Klabzuba chair and Stubbeman-Drace Presidential Professor of Geosciences, is a planetary geologist best known for her ongoing work with NASA's Mars Rover mission. Her research on brines and mineral-fluid interactions has implications and applications for geothermal systems. Likewise, assistant professor Kato Dee uses geochemical modeling to better understand geothermal systems.

Geophysics Insights for Geothermal Energy

Heather Bedle, geophysicist and assistant professor at the School of Geosciences, is working with her students to create detailed subsurface geologic reservoir characterization models, which will help identify potential geothermal energy targets based on below-ground geological features. In addition, her team with the Attribute-Assisted Seismic Processing and Interpretation research consortium is creating workflows to help geoscientists better identify faults and fractures in the subsurface.

Geology Insights for Geothermal Energy

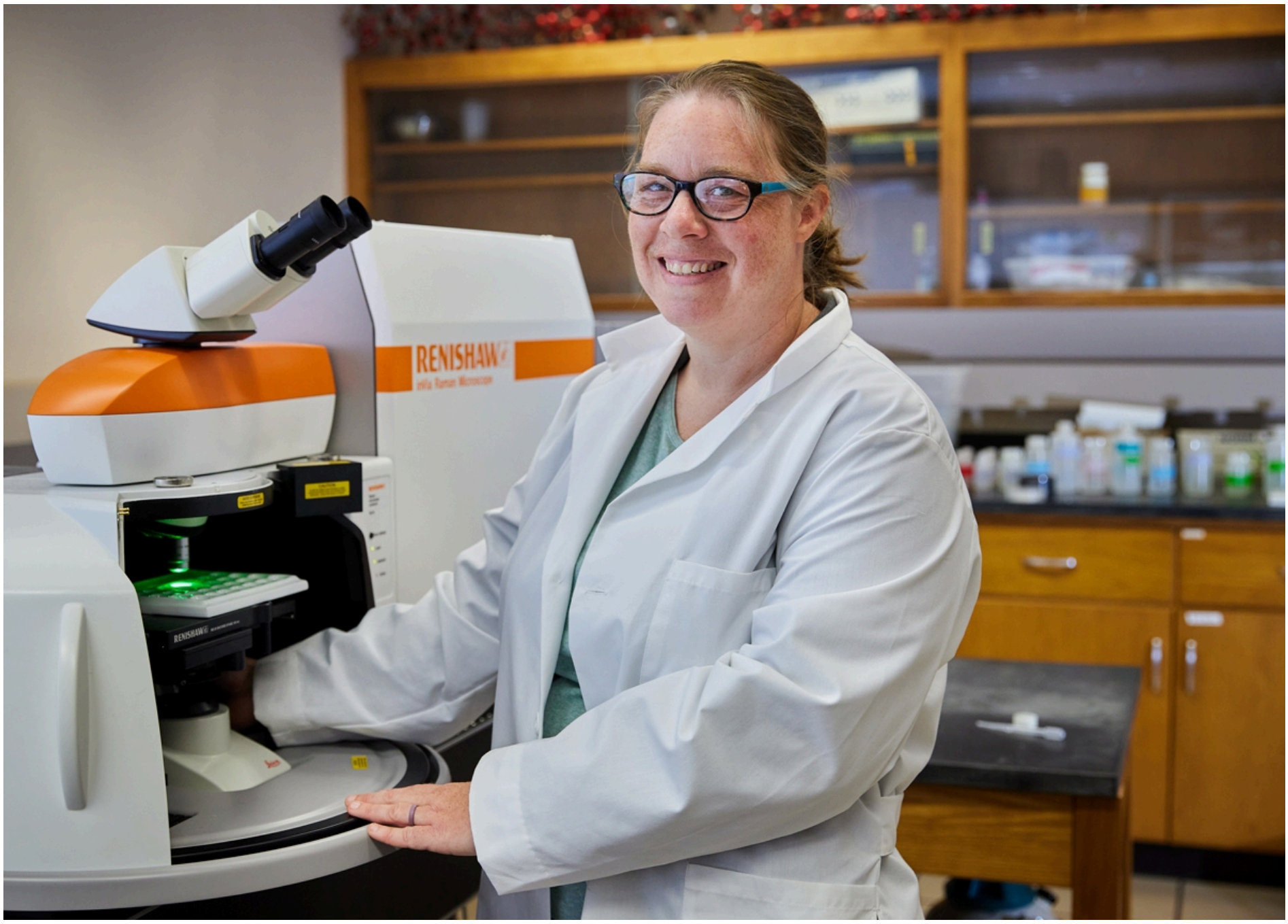
According to John Pigott, associate professor in the School of Geosciences, "Oklahoma has significant economic geothermal energy potential in those regions of the state where the subsurface temperature exceeds a critical temperature of 126.8 degrees C."

While there are thousands of records of temperatures taken at specific well sites, these old data points cannot be relied upon for a variety of reasons. When the oldest of the well temperatures were collected, scientists believed that temperatures were static at certain depths. For example, they believed the temperature 10,000 feet below the surface would be the same throughout Oklahoma.

"This is not the case, ever," said Pigott. Rather, temperatures vary based on many factors, most notably, the type of rock in an area. Some rocks conduct and transfer heat and some do not. However, researchers now have the tools to accurately predict geothermal temperatures in large areas through a modeling process called heat flow thermal conductivity correction.

"This has never been done rigorously in Oklahoma," said Pigott. "If funding were available, it could easily be done in one year using 3D basin modeling software that we have here at OU."

Professor and Victor E. Monnett Chair in Energy Resources Matthew Pranter is using his expertise in petroleum geosciences to focus on subsurface characterization and 3D modeling of geological formations that form petroleum and geothermal reservoirs.



Megan Elwood Madden

“As the world’s first petroleum geology program, the OU School of Geosciences has decades of history in subsurface reservoir characterization and modeling, and we are expanding on this expertise,” said Pranter. With Fnu Suriamin, senior research geologist with the Oklahoma Geological Survey, they are exploring the potential of geothermal resources in deep sedimentary basins for both power and heat.

Serving Oklahoma

Along with dynamic and interdisciplinary research projects that are sure to impact Oklahomans, the University of Oklahoma is already serving the community through its work in the geothermal energy space.

Oklahoma Geological Survey

In addition to the expertise of the researchers and longstanding relationships between the university and industry leaders, Oklahoma Geological Survey resources are a differentiator for the state’s growth in geothermal energy.

OGS resources such as the Oklahoma Petroleum Information Center, which houses more than 100 miles of core from almost 10,000 Oklahoma wells, samples from over 50,000 wells, as well as logs and historical field reports, provide a wealth of data for the public, including OU researchers. Experts from OGS can consult in the areas of cartography, 3D modeling, and the use of the state’s seismicity network.

“We are ready to provide resources and to collaborate with engineers and geoscientists to make geothermal energy a reality in Oklahoma,” said Oklahoma Geological Survey Director Nicholas Hayman.

Geothermal Rising

Mewbourne College students in the OU Geothermal Rising chapter competed in and won the 2022 Department of Energy Geothermal Collegiate Competition in which they designed and proposed a system to repurpose six abandoned oil and gas wells in Shawnee, Okla. to provide clean, renewable geothermal energy within the Absentee Shawnee Tribe and Potawatomi Nation jurisdiction. OU Geothermal Rising students also developed a classroom curriculum for Shawnee High School that will be implemented in the school’s career exploration course.

The OU Geothermal Rising team is hosting a stakeholder engagement event on Sept. 2 on the OU Norman campus. It will feature speakers from the Department of Energy, National Renewable Energy Laboratory, the Citizen Potawatomi Nation and Shawnee Public Schools.

“Our award-winning Geothermal Rising team exemplifies the creativity and innovation of all Mewbourne College students. I know without a doubt that the students coming out of this college will use that same creativity to find solutions for challenges we face today and in the

The OU Geothermal Team, (L-R), Esteban Ugarte, Abdelmjeed Mohamed, Camila Castillo, Karelia La Marca, Alex Cedola, Cesar Vivas Munar and Yuxing Wu.

sustainable energy at home and around the world," said MCEE Dean and Lester A. Day Family Chair at Mewbourne College J. Mike Stice.

Saeed Salehi (left) and doctoral student Majeed Mohmed (right), working on a geothermal project related to fluid flow in geothermal wells and testing of lost circulation materials. Image by Travis Caperton.

Geothermal Energy Creates Economic Diversity and a Nimble Workforce

Oklahoma's long history in the oil industry has created a skilled local workforce that is essential to the success of Oklahoma's efforts in geothermal energy. Likewise, geothermal energy also provides a new application for the state's energy workforce.

"Before joining the OU Geothermal team, I did not understand just how closely related geothermal engineering and petroleum engineering are," said petroleum engineering graduate student and member of Geothermal Rising, Alex Cedola. "I am now even more excited to get into the energy industry after I graduate."

Doctoral candidate Cesar Vivas Munar, who works with Salehi and participated in the Geothermal Rising competition, echoed Cedola's sentiments. "The exciting thing is that we are using petroleum engineering tools, software and knowledge. It is easily transferred into geothermal applications. Our skills are transferable. This is an opportunity for petroleum engineering students, people already in the industry, and energy companies throughout Oklahoma."

The opportunities for geothermal energy in Oklahoma abound. Whether creating new energy sources or giving life to oil wells once thought depleted, the University of Oklahoma is engaged and already leading in the area of geothermal energy. And it is just the beginning. In fall 2024, Mewbourne College plans to launch a revolutionary new undergraduate degree program called GeoEnergy Engineering that will prepare a new generation of geothermal experts.

"Any legislation that supports the development of geothermal energy to meet growing energy demands will be a positive contributor to our environment and our economy," said Stice.

Written by Sarah Warren, director of communications and events for Mewbourne College of Earth and Energy.

To learn more about geothermal energy research, education and service at OU, contact **sarah.warren@ou.edu** or Chelsea Julian, director of marketing and communications for the Vice President for Research and Partnerships, at **chelseajulian@ou.edu**

Further Reading

Learn more about the specifics of geothermal Energy in Oklahoma:

Vox: Clean energy is buried at the bottom of abandoned oil wells

Sooner Magazine: How do you make a lot of deep holes in the ground useful again?

Mewbourne College News: OU Researchers Receive Department of Energy Grant to Pioneer Demonstration and Repurposing of Retired Oil Wells into Geothermal Wells

Mewbourne College News: OU Researcher Receives Part of $28 Million Grant to Increase Geothermal Energy Production in the United States

OU Research News: OU Geothermal Team Wins First Place in National Department of Energy Competition

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Vice President for Research and Partnerships
Five Partners Place
201 Stephenson Pkwy
Norman, OK 73019-9705

Updated 9/1/2022 by Vice President for Research and Partnerships: researchnews@ou.edu