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Energy Subcommittee

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Good afternoon, Chairman Williams, Ranking Member Bowman, and Members of the Subcommittee. Thank you for the opportunity to testify today on the future of subsurface science and technology in the United States.

My name is Dr. Kevin Rosso and I am an Associate Director of the Physical Sciences Division at the Department of Energy's (DOE) Pacific Northwest National Laboratory (PNNL). I have worked at PNNL for 25 years, and lead a group of about 35 geochemists in topics such as predicting carbon dioxide (CO_2) mineralization rates for geological storage, chemical transformations of nuclear waste for processing, and transport of hazardous materials in the subsurface. The work is fundamental in nature, in that we seek to develop the basic knowledge needed for transformational advances. We also work closely with colleagues in the applied sciences to help translate discoveries into practical solutions.

Today I would like to focus my testimony on two main concepts:

1. The subsurface is complex, and the challenges facing new energy system development below ground are substantial. But thankfully, key areas where technical innovations are needed are largely understood by the scientific community.
2. Success requires a sustained, concerted multi-disciplinary research and development (R&D) effort between national labs, universities, and industry. Facilitating the formation of robust and meaningful partnerships will accelerate advances.

Resources in the subsurface have been meeting most of our essential needs, including for energy, clean water, raw materials for construction, and critical elements, to name a few. For many years we have been prolific masters of finding and unearthing these resources, with relative ease.

But we now look to the subsurface for entirely new purposes, purposes that come with unique challenges. We seek to tap its abundant heat for clean geothermal energy. We also seek to use it for storage of energy from intermittent sources such as wind and solar, and for disposal of hazardous materials including excess CO_2 and radioactive waste. And we need to be able to do these things safely, efficiently, at large scales, and with minimal environmental impact. Exciting examples demonstrating promise are emerging both at home and abroad, including PNNL's Wallula CO_2 injection pilot in Washington which showed rapid carbon mineralization in basalt, and Fervo Energy's enhanced geothermal energy pilot in Nevada which just completed a successful month-long well test. But, to be clear, we are still just explorers, facing new unknowns.

Subsurface environments are structurally and chemically complex and we have limited ability to see important features deep below or predict their physical and chemical responses to change. Nonetheless, to create an enhanced geothermal system, for example, requires that we accurately drill deep into hard rock, create an interconnected and permeable fracture network, and circulate fluid that brings up sufficient heat sustainably for years. All the while, we must avoid triggering earthquakes, or loss of fluids, flow, or heat transfer over time. It is this need for predictive control and long-term reliability that makes it a new ballgame.

Mastering this at the national scale requires that we learn how to overcome the many uncertainties involved in subsurface engineering. We need to go beyond what industrial R&D can achieve alone. Recognizing this, the DOE has been proactive in cultivating and supporting relevant fundamental and applied subsurface R&D to help fill the most critical gaps. Examples include its 2014 Subsurface Science, Technology, Engineering Research and Development (SubTER) initiative, which identified "adaptive control of subsurface fractures and fluid flow" as its core objective. In 2015 DOE's Office of Basic Energy Sciences, Geosciences program led the report *Controlling Subsurface Fractures and Fluid Flow: A Basic Research Agenda,* to define the basic research needed to achieve this goal.

Many of the resulting research priorities were recently featured in funding opportunity announcements from DOE's Energy Earthshot Initiative, to which PNNL responded with a multi-institutional team to develop novel signal detection methods to enable real-time monitoring of the state of stress between boreholes. Success of such efforts could provide breakthroughs for predicting the evolution of fracture flow and heat transfer over the long-term for enhanced geothermal reservoirs. But this is just one piece of the larger R&D landscape required to take us from explorers to masters.

As the nation's R&D community continues to rally and drill deep into these key subsurface science challenges, it feels timely in this venue to emphasize the importance of keeping our nation's R&D infrastructure at the bleeding edge. Key to this effect is ensuring new and advanced experimental and computational capabilities continue at our national labs and universities, including ongoing and future upgrades at DOE national user facilities. This will help keep the nation at the forefront, in particular by maintaining our ability to attract and retain top talent from the competitive, international environment in which we now operate.

In conclusion, largely overlooked, the subsurface provides most of the critical resources sustaining our way of life. It is also the foundation for our future. Our ambition to use it in new ways, for new sources of energy and for safe storage, is a vital but grand challenge that requires all our attention and commitment to a national team-science R&D effort.

Thank you for the opportunity to provide the Committee with information on this topic. I would be happy to answer any questions that you may have.