

OCTOBER 8, 2019

National Academy of Sciences Building
Room 120; 2101 Constitution Ave NW
Washington, DC**Characterization and management of the subsurface:
Insights from the development of geothermal, oil and gas, and mineral resources**

Geothermal energy is a versatile renewable energy resource that provides baseload power for electricity generation and can also be used for a range of heating and cooling applications in commercial and residential settings. Because geothermal energy relies on capturing the natural heat of the Earth, exploration for and development of geothermal resources requires extensive knowledge of the Earth's subsurface, including the mechanical, thermal, and chemical behavior and characteristics of rocks and fluids; dynamic processes such as those related to volcanic and hydrothermal systems; and impacts of changes to the subsurface as it is engineered to extract energy.

Development of advanced approaches for exploration and production of oil and gas and non-fuel mineral resources shares many similarities with those required for geothermal energy development particularly in terms of the need for improved understanding of the subsurface and the way rocks and fluids interact and behave in natural and engineered situations. With a foundation provided through an update on the status of new research within conventional geothermal and enhanced geothermal systems, our discussion will take a cross-sectoral approach from geothermal, oil and gas, and mining perspectives to highlight progress, challenges, and opportunities in:

- Managing uncertainty in subsurface data;
- Advances in technologies for subsurface characterization; and
- Dynamic permeability in fractured reservoirs

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09:00 AM	Welcome and Introductions	Jim Slutz , Committee Chair Franklin "Lynn" Orr , Chair National Academy of Engineering Earth Resources Engineering section
09:20 AM	Invited presentation: Geothermal energy— Research and development advances	Susan Hamm , Director Department of Energy Geothermal Technologies Office

PANEL SESSIONS

09:55 AM	PANEL 1: Managing uncertainty in subsurface data Uncertainty in geological and geomechanical models of the subsurface affects well siting and targeting of geothermal, hydrocarbon, or mineral resources, as well as estimates of resource temperature, volume, ore grade, etc. What are the best approaches to ensure that uncertainty across all data-types and phases of resource exploration and development is properly captured in the sub-surface model(s) and is used effectively to guide resource development decisions? <ul style="list-style-type: none"> • Colin Williams, U.S. Geological Survey • Ken Witherly, Condor Consulting • Jeffrey Yarus, Case Western Reserve University 	Moderator: David Spears, Committee member
11:00	Break	
11:15	PANEL 2: Advances in technologies for subsurface characterization Technologies and approaches used for mineral, geothermal, and hydrocarbon resource exploration are continually advancing, facilitated by improved resolution and fidelity of surface data acquisition techniques (e.g. geophysical), innovative downhole logging tools and wellbore instrumentation, new data processing algorithms and integration methods, and updated conceptual understanding of resource occurrence models. These incremental technological advances collectively continue to reduce resource exploration risk, by improving resource targeting and well design, and supporting the exploration and development of more technically-challenging and/or sub-commercial resource prospects. <ul style="list-style-type: none"> • Jim Faulds, Nevada Bureau of Mines and Geology • Azadeh Riahi, Itasca Consulting Group, Inc. • Ken Witherly, Condor Consulting 	Moderator: Joel Renner, Committee member
12:20 PM	LUNCH	
1:20 PM	PANEL 3: Dynamic permeability in fractured reservoirs Dynamic permeability is the change in permeability that occurs through natural or induced processes in the subsurface. In the geothermal and unconventional petroleum sectors, dynamic permeability becomes an important factor during the reservoir development (stimulation and fracture creation) and production phases of a project. Coupled thermal-hydrologic-mechanical-chemical (THMC) processes in engineered fracture networks can serve to either increase or decrease permeability through time, both of which are typically undesirable and can negatively-impact reservoir sustainability. In Engineered Geothermal Systems (EGS), dynamic permeability is particularly challenging because in EGS reservoirs, heat exchange area and permeability need to be managed simultaneously—a formidable task. <ul style="list-style-type: none"> • Pengcheng Fu, Lawrence Livermore National Laboratory • Christine Ehlig-Economides, University of Houston • Fikri Kuchuk, Schlumberger (retired) 	Moderator: Bridget Ayling, Committee member
2:25 PM	BREAK	
2:45 PM	Plenary discussion led by Bridget Ayling	
3:30 PM	End of formal discussion	

END OF MEETING