VANDERBILT
School *of* Engineering

Civil & Environmental Engineering Seminar Series
Co-sponsored with VSEC Funding

VANDERBILT CENTER FOR
Sustainability, Energy and Climate

Monday,
November 16
1:15 pm
FGH 129

"UNLOCKING THE POWER BENEATH OUR FEET"

DR. DAVID MCNAMARA

ASSOCIATE PROFESSOR
HEAD OF EARTH SCIENCE RESEARCH GROUP
DEPUTY DIRECTOR, SEM SHARED RESEARCH FACILITY
OCEAN, EARTH & ECOLOGICAL SCIENCES, UNIVERSITY OF LIVERPOOL, UK

ABSTRACT

The subsurface contains an enormous store of geothermal energy, yet geothermal remains relatively underused compared with many other low-carbon energy sources. The challenge is not simply whether heat exists beneath our feet, but whether it can be accessed and whether fluid pathways can be found, created and maintained efficiently, economically, and safely.

I will explore why geothermal energy has historically developed slowly, why interest is increasing now, and how advances in subsurface science and technology may help expand its use. Drawing on examples from my own research, I will focus on one of the central geological challenges in geothermal development: understanding how permeability is generated, distributed, and modified within the subsurface. In many geothermal reservoirs, fluid flow is dominated by faults and fractures rather than by intact rock matrix. My research examines how fracture geometry, structural complexity, and in-situ stress control where geothermal fluids move, how permeability can be localized around fault intersections and critically stressed structures, and how changes in stress can alter fracture behavior and fluid transmissivity. I will also explore how processes affecting geothermal reservoirs operate from the micrometer scale of mineral nucleation and crystal growth, through individual fractures and fracture networks, to kilometer-scale reservoir systems. Studies of fracture systems show that different geological controls emerge at different scales of observation, while laboratory experiments demonstrate how fracture roughness and effective pressure strongly influence fluid transmissivity. As geothermal reservoirs are dynamic systems, fluid pathways can open, close, reactivate or become sealed as stress conditions change, and minerals precipitate from circulating fluids. Work on active and exhumed geothermal systems shows how repeated fracture opening, mineralization and sealing can redistribute permeability through time, while microanalytical studies of calcite growth demonstrate how processes at the fracture wall can ultimately influence reservoir-scale flow. Importantly, integration of geological models can help identify favorable combinations of heat, permeability, and fluid before expensive drilling takes place, reducing uncertainty in geothermal exploration. Lastly, these scientific challenges must be contextualized within the broader context of geothermal deployment, including technological development, exploration risk, environmental impacts, public acceptance, and the potential for institutions such as universities to act as demonstrators for geothermal heating, thermal storage and wider decarbonization.

BIOGRAPHY

David McNamara is a geologist and Associate Professor at the University of Liverpool whose research focuses on geothermal systems, subsurface fluid flow, fracture networks, and rock–fluid interactions. His work investigates how geological structure, stress, fracture properties, mineral alteration, and rock physical properties influence the behavior and long-term evolution of geothermal reservoirs.

A particular focus of his research is understanding how observations made across very different scales, from mineral interfaces and individual fractures to boreholes, fault networks and whole reservoirs, can be integrated to better understand subsurface permeability. His work combines field geology, borehole imaging, laboratory rock-physics experiments, microscopy and microanalysis, and reservoir-scale structural interpretation, with research spanning geothermal systems in New Zealand, the USA, Chile, and elsewhere.