NATIONAL ENERGY TECHNOLOGY LABORATORY

Subsurface Engineering

NETL is advancing subsurface engineering to unlock the full potential of America's underground resources, supporting increased hydrocarbon recovery, critical mineral recovery, and resource production. Through a unique combination of geoscience expertise, engineering innovation, and advanced simulation capabilities, NETL delivers technologies that help ensure well integrity, optimize resource extraction, and expand domestic supply chains. These efforts help improve access to domestic resources, improve infrastructure resilience, and support U.S. energy and economic security.

R&D Applications

- Reservoir Engineering and Enhanced Oil Recovery
- Subsurface Imaging and Monitoring
- Produced Water Management and Reuse
- Well Integrity and Remediation
- Oil and Natural Gas Recovery
- Natural Resource Assessment and Monitoring
- Unconventional Sources for Critical Minerals and Rare Earth Elements
- Geothermal Energy
- Strategic Storage for Hydrogen and Natural Gas
- AI/ML to Maximize Coal Mining Productivity
- Enhanced Coal Bed Methane Recovery
- Improving Access to Unmineable Coal Seams

NETL researchers study techniques for enhanced hydrocarbon recovery to maximize production.

Researchers use the High-Pressure Immersion and Reactive Transport Laboratory to study subsurface systems.

Unconventional Resource Prediction Using Machine Learning

NETL's Unconventional Rare Earth Element and Critical Minerals Resource Assessment Tool uses machine learning-based analysis of key subsurface properties and geologic characteristics to predict resource prospects throughout the country. This model helped uncover the largest unconventional deposit of magnetic rare earth elements in the U.S. The models have been expanded for use for groundwater, hydrocarbons, geothermal, and more.

Research Highlights

Research Reduces Risk in Tertiary Oil Recovery and In-Situ Critical Minerals Recovery

Strengths in modeling and artificial intelligence (AI) allow NETL to enable American energy security in oil and natural gas and critical minerals recovery. Through measured information that quantifies how a system works or responds to an event compared to known technical principles, researchers can evaluate system economics to develop estimates of reservoir reserves. The models and scans can help increase domestic oil supplies while reducing environmental and safety risks.

Fluid Transfer in Tight Shale

NETL's unique geological imaging capabilities are able to capture fluid migration in low-permeability shales due to mechanical stressing and fluid pressurization. This collaborative research between NETL and ExxonMobil Technology and Engineering Company describes gas transport between fractures and shale under stresses representative of fluid pressures in the subsurface. This work helps develop new techniques to interrogate phenomena at sub-micron scales and improve understanding of the compositional and mechanical conditions of natural materials that influence fluid transport in subsurface energy operations.

Pinpointing Corrosion to Enhance Pipeline Safety

NETL's multiparameter optical fiber sensor provides a revolutionary approach to pinpoint early signs of corrosion in natural gas pipelines before catastrophic failures can occur, significantly enhancing the safety, reliability, and resilience of crucial energy infrastructure. Unlike conventional sensors that detect only one variable, the NETL system can monitor direct corrosion, humidity, and water presence simultaneously along the entire length of the pipeline, offering both direct diagnosis and predictive insights so operators can intervene before significant corrosion occurs.

Subsurface Trend Analysis (STA) Method and Tool

The STA workflow uses deep learning and AI-informed image segmentation to predict and analyze subsurface and offshore conditions. The STA has demonstrated the ability to extract and accurately label images with 90% to 95% accuracy, improving subsurface property analysis for resources, geohazard predictions, and real-time drilling risk reductions. This information increases safety and efficiency of operations while reducing risk and cost.

Publications

- Fritz, A. G., Tarka, T. J., & Mauter, M. S. (2023). Assessing the economic viability of unconventional rare earth element feedstocks. *Nature Sustainability, 6(9)*, 1103-1112. https://doi.org/10.1038/s41893-023-01145-1.
- Goodman Hanson, A., Kutchko, B., Lackey, G., Gulliver, D., Strazisar, B. R., Tinker, K. A., Wright, R., Haeri, F., Huerta, N., Baek, S., Bagwell, C., de Toledo Camargo, J., Freeman, G., Kuang, W., Torgeson, J., White, J., Buscheck, T. A., Castelletto, N., & Smith, M. (2022). *Subsurface hydrogen and natural gas storage (state of knowledge and research recommendations report)*. National Energy Technology Laboratory. https://doi.org/10.2172/1846632.
- Kim, K-J., Huynh, N. T., Lee, Y., Nguyen, T., Pham, V. H., Gao, Y., Li, Y., Bhandari, G., Wang, C., & Matranga, C. (2026). Highly crystalline, low-ash, graphite from coal using an Fe_2O_3-based catalytic process with recovery and reuse of catalyst and process acid. *Carbon, 246*, 120920. https://doi.org/10.1016/j.carbon.2025.120920.
- Moore, J., Crandall, D., Sanguinito, S., & Valenza II, J.J. (2023). Fracture-matrix fluid exchange in oil-bearing unconventional mudstones. *Scientific Reports 13*, 21708. https://doi.org/10.1038/s41598-023-48688-z.
- Pantaleone, S., Choisser, A. C., Marcelli, O., Rose, K., & Morkner, P. (2024). *Prospective seal name catalog for U.S. sedimentary basins V1.0.* National Energy Technology Laboratory, https://edx.netl.doe.gov/dataset/prospective-seal-name-catalog-for-us-sedimentary-basins, DOI: 10.18141/2311187.

NETL is a U.S. Department of Energy (DOE) national laboratory dedicated to innovating and accelerating the nation's energy solutions in hydrocarbons, geothermal energy, and critical minerals production. The Lab further strengthens its impact by engaging with industry, academia, and other stakeholders through four strategically located Centers of Excellence: Coal, Critical Minerals & Advanced Alloys, Oil & Gas, and Geothermal. With research sites in Albany, Oregon; Morgantown, West Virginia; and Pittsburgh, Pennsylvania, NETL operates as one laboratory to create advanced energy technologies that support DOE's mission and enable affordable, reliable and, secure energy to fuel human prosperity.

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