



**Pacific
Northwest**
NATIONAL LABORATORY

Working with National Labs to Advance Next Generation Mining Technologies

DOE Alaska Workshop on Critical Minerals
Anchorage, AK | 09 May 2024

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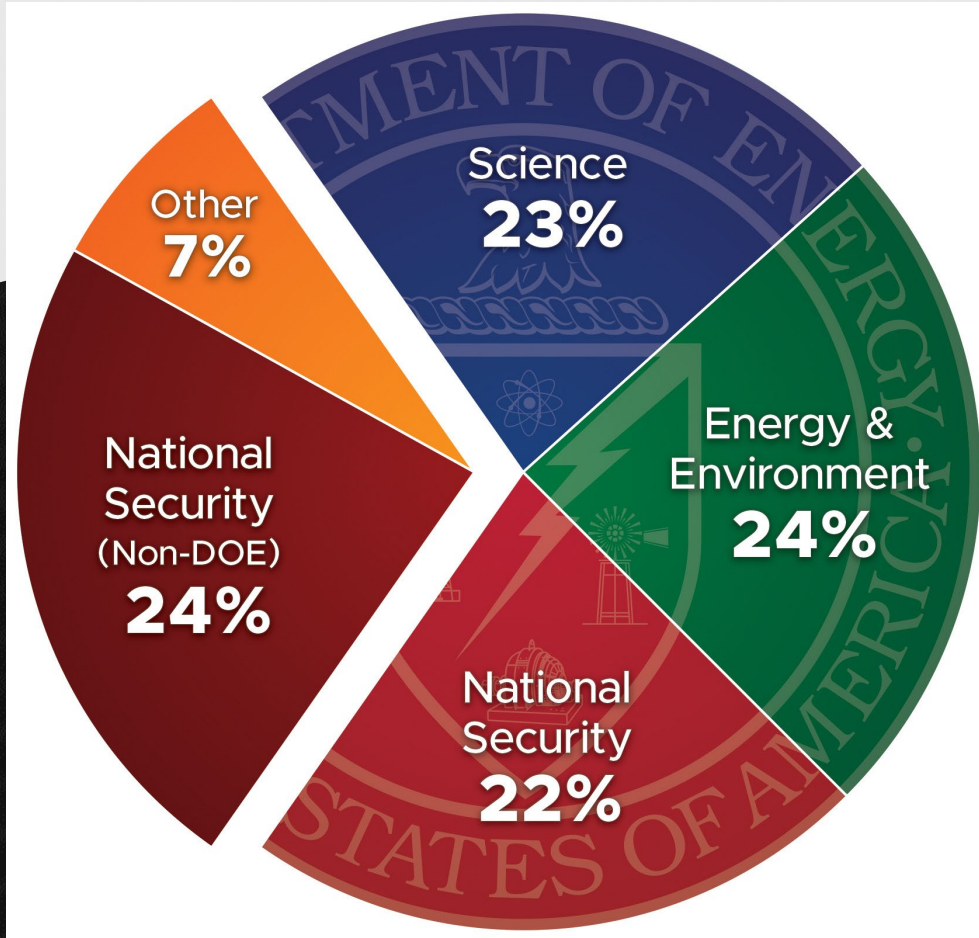
PNNL-SA-168920

PNNL and NETL are two of DOE's 17 national laboratories

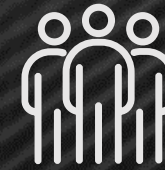




PNNL is DOE's most diverse national laboratory



Staffing, FY 2023



6,088 Staff



\$1.5B Spending



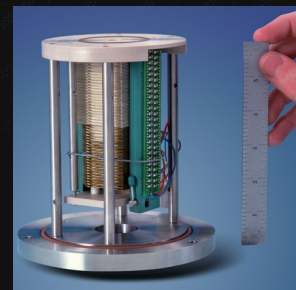
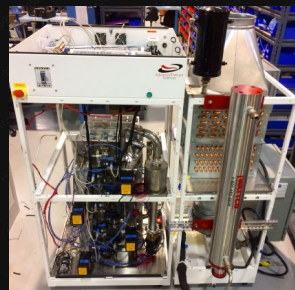
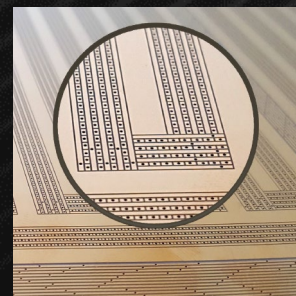
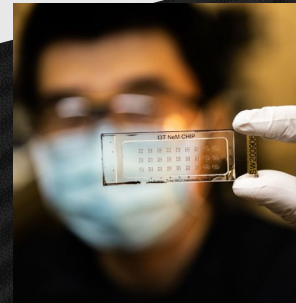
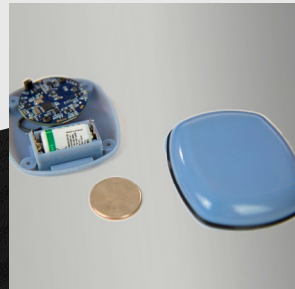
1,980 Peer-reviewed publications



301 Invention disclosures



PNNL remains focused on DOE's deployment and commercialization missions



In FY 2023:



73

U.S. and International Patents



13

Licenses and Options

ONE
INVENTION
nearly every day

Nearly
1.5
PATENTS
received per week

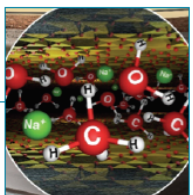
99
Active
BUSINESSES
with PNNL roots
since 1965

As a DOE Office of Science Lab PNNL leverages best in class chemistry and materials capabilities



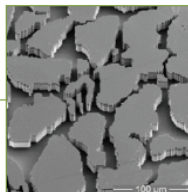
COMPUTATIONAL CHEMISTRY

- Solvent optimization
- Alloy discovery
- Polymer chemistry



PORE SCALE PROCESSES

- In situ microfluidics
- Water film geochemistry
- Carbonation rates
- Novel subsurface signatures



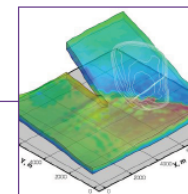
DESIGN AND SYNTHESIS

- Solvent development
- Solid phase processing
- SOFC materials
- Polymer chemistry
- Separations technologies



PROJECT SPECIFIC ENGINEERING

- Reactive transport modeling with STOMP
- Tools for improving solid oxide fuel cell reliability
- Radically engineered modular systems
- Multi-scale CO₂ capture modeling platform

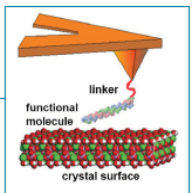


PARTNERS



ADVANCED IMAGING TECHNIQUES

- Liquid cell Transmission Electron Microscopy
- Atom probe tomography
- Secondary Ion Mass Spectroscopy
- Ion Probe



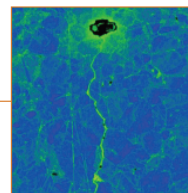
PROBING IN SITU REACTIONS

- Fracture initiation and propagation
- Gas induced structural changes
- Mineral nucleation



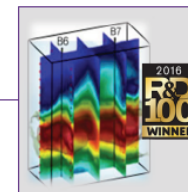
EXTREME ENVIRONMENTS

- Flow-through mechanics and chemistry
- Materials performance at service conditions
- Stress corrosion cracking

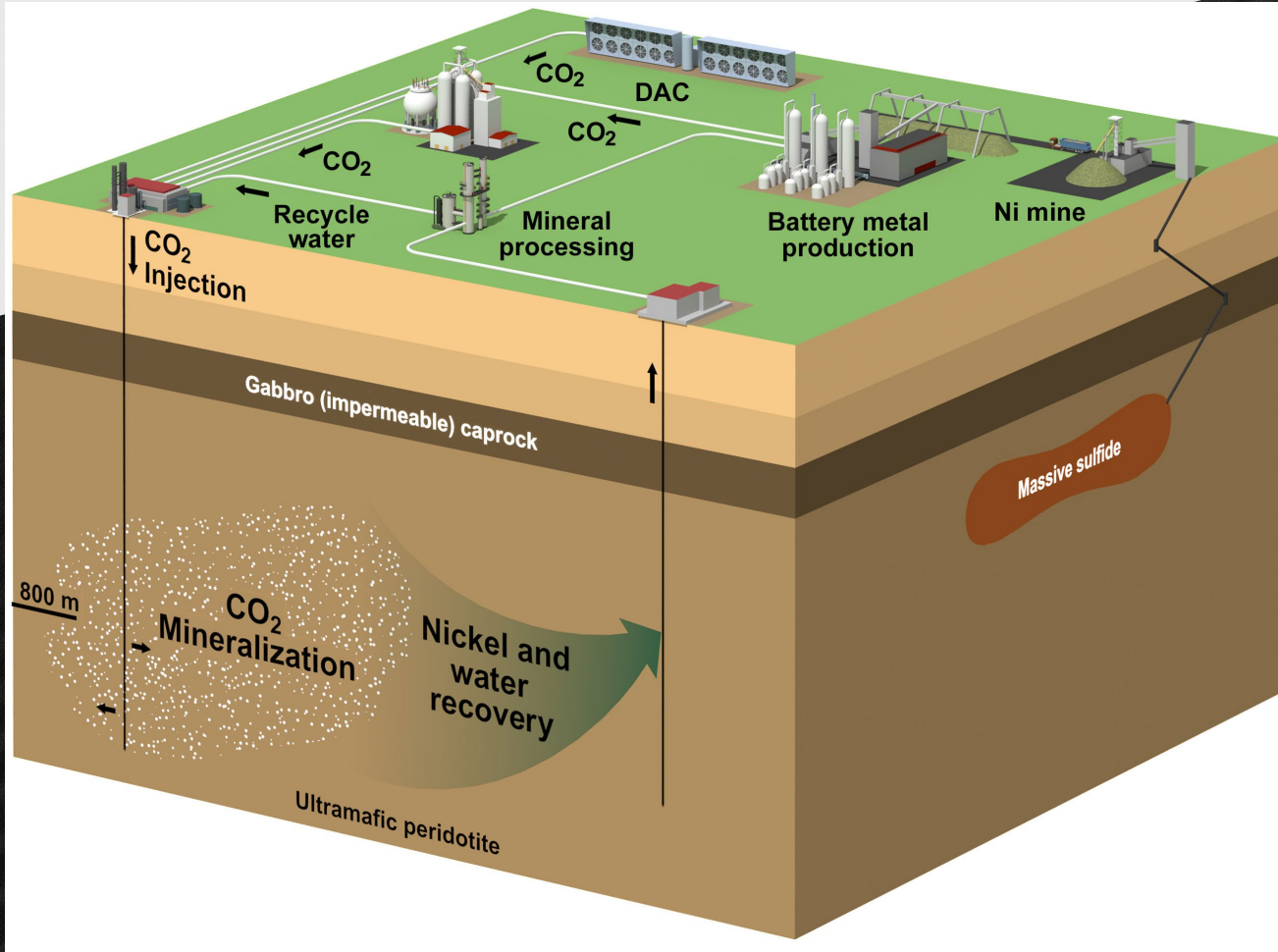


OPTIMIZING OPERATIONS

- Real-time subsurface intelligence
- Cost-optimized monitoring design
- Improving commercial solvent efficiency



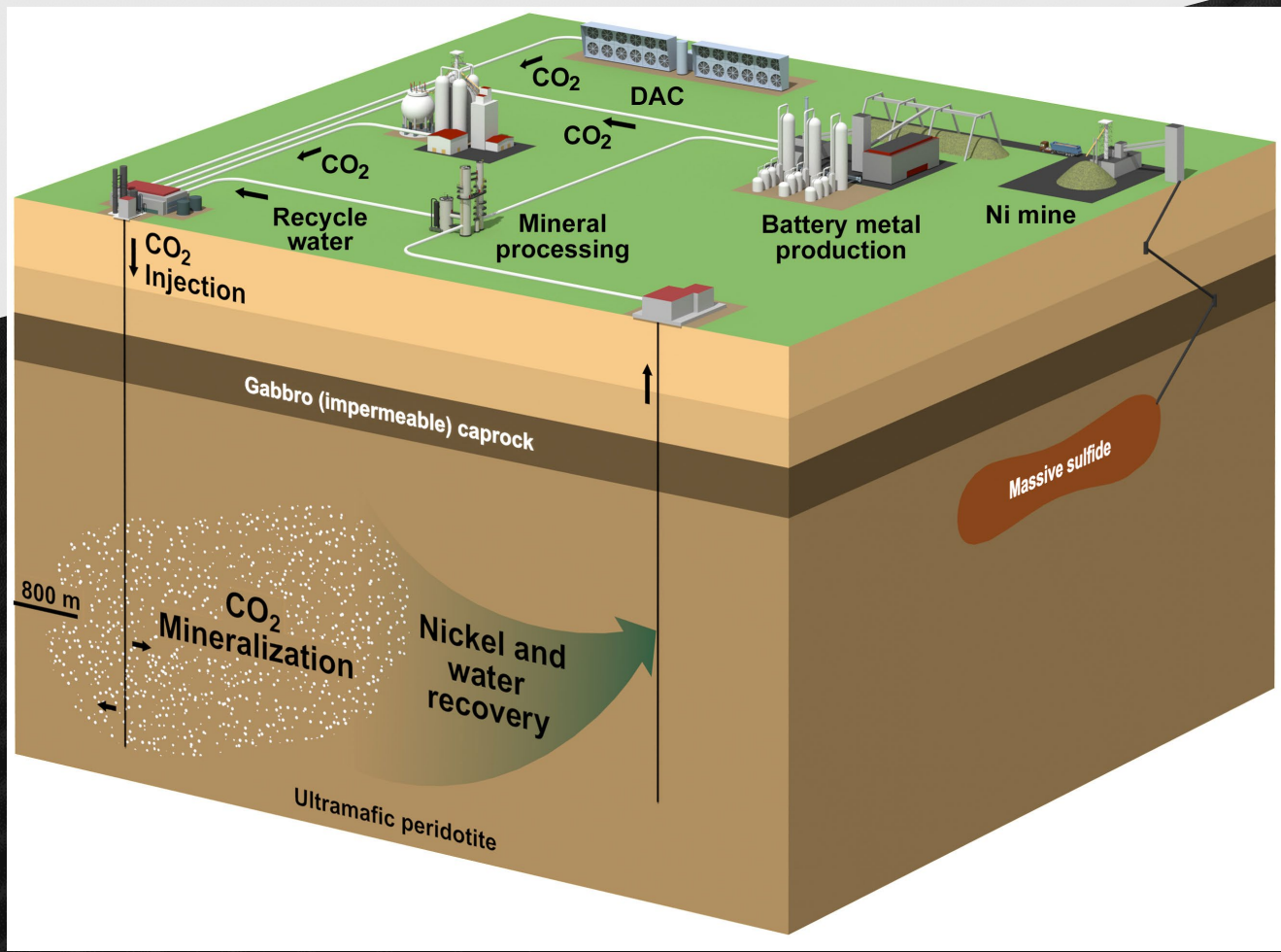
PNNL remains focused on DOE's deployment and commercialization missions



- Developing a comprehensive suite of methods to determine the feasibility of in situ scCO₂-Enhanced Mineral Recovery (scCO₂-EMR) and permanent CO₂ storage by mineralizing mafic-ultramafic targets
- Targeting low grade ores (ultramafic rocks) vs. high grade sulfide or laterite ores
- Ultramafic rocks are rich in olivine
 - Olivine contains significant (up to 7000 ppm) Ni
 - Olivine will readily react with CO₂ to form carbonate minerals



PNNL remains focused on DOE's deployment and commercialization missions



- 1 km³ block of olivine, olivine contains 3000 ppm Ni
- Calculate the total amount of Ni produced from and CO₂ stored in that volume

% Rock Reacts with CO ₂	Ni Produced (MMT)	CO ₂ Stored (MMT)
100%	10	2000
50%	5.0	1000
10%	1.0	200
5%	0.50	100

~3X of U.S. Nickel Production
~1/6 of Global Nickel Production



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