THE FUTURE LIES BENEATH

Introduction to ARPA-E subsurface programs

ARPAE

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Program Director, ARPA-E
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THE FUTURE

Why are we here?

What are you going to do about it?

We’ve laid a table for you to feast on

Universities

Fellow Researchers

Program Directors

Geologists

USGS

People Digging

Chemists

DOE

Big Companies

Investors

Engineers

DoD

Startups

Small Companies

People Drilling

National Labs

We've laid a table for you to feast on

YOU

Talk, plan, connive, correspond, collaborate with others you meet here

History of subsurface and critical mineral technologies at ARPA-E

Downhole tools

OPEN 2018

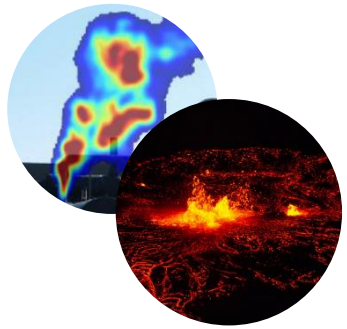
Biomining
MIDAS
WiX

OPEN 2021

MINER

GOPHURRS

GeoH$_2$



H2SENSE
SUPERHOT
VISION OPEN

2018 2019 2020 2021 2022 2023 2024 2025

~~History~~ of subsurface and critical mineral technologies at ARPA-E

FUTURE

Tell us what's missing, what is needed, what we can transform

ARPA-E Subsurface Team

Program Directors


Doug Wicks


Rob Mellors


Emily Kinser


Jo Sharma

Technology-to-Market Advisors


Othon Monteiro


Matthew Hackworth

Fellows


Ryan Chaban


Carlos Díaz-Marín

Technical support staff


Lipi Acharya


Sam Falzone

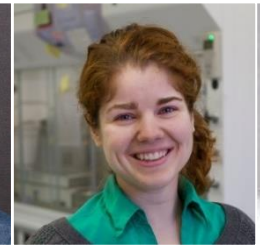

Yasheen Jadidi


Eaman Karim


Dien Li


Toni Marechaux


Truong Nguyen


Kate Pitman


Kalena Stovall


Mervin Zhao

Unpictured: Project management, events, and communications support staff

ARPA-E Subsurface Team

Program Directors

Rob Mellors | Emily Kinser | Jo Sharma

Technology-to-Market Advisors

Cayle Bradley | Matthew Hackworth

Fellows

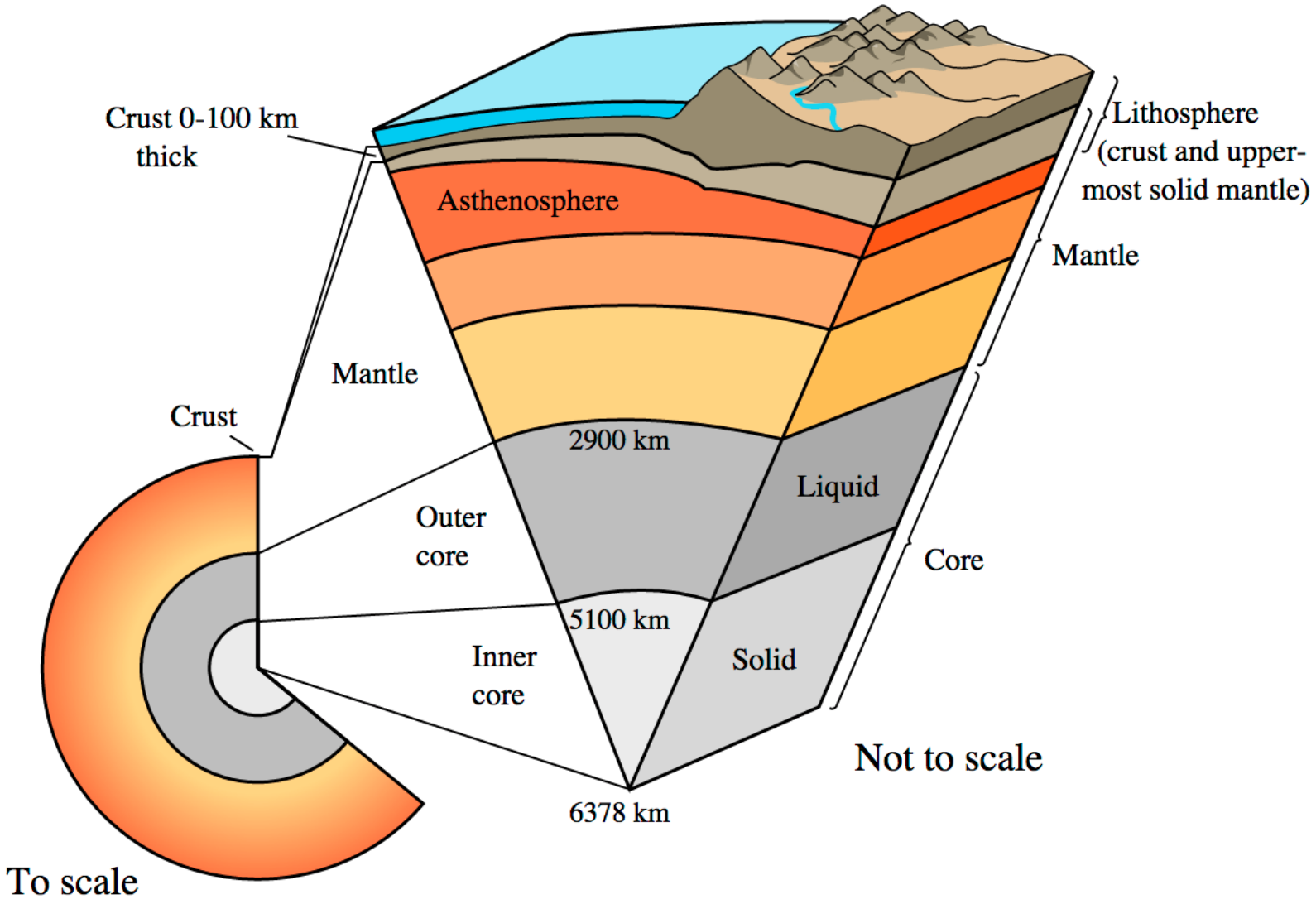
Ryan Chaban | Carlos Díaz-Marín

Technical support staff

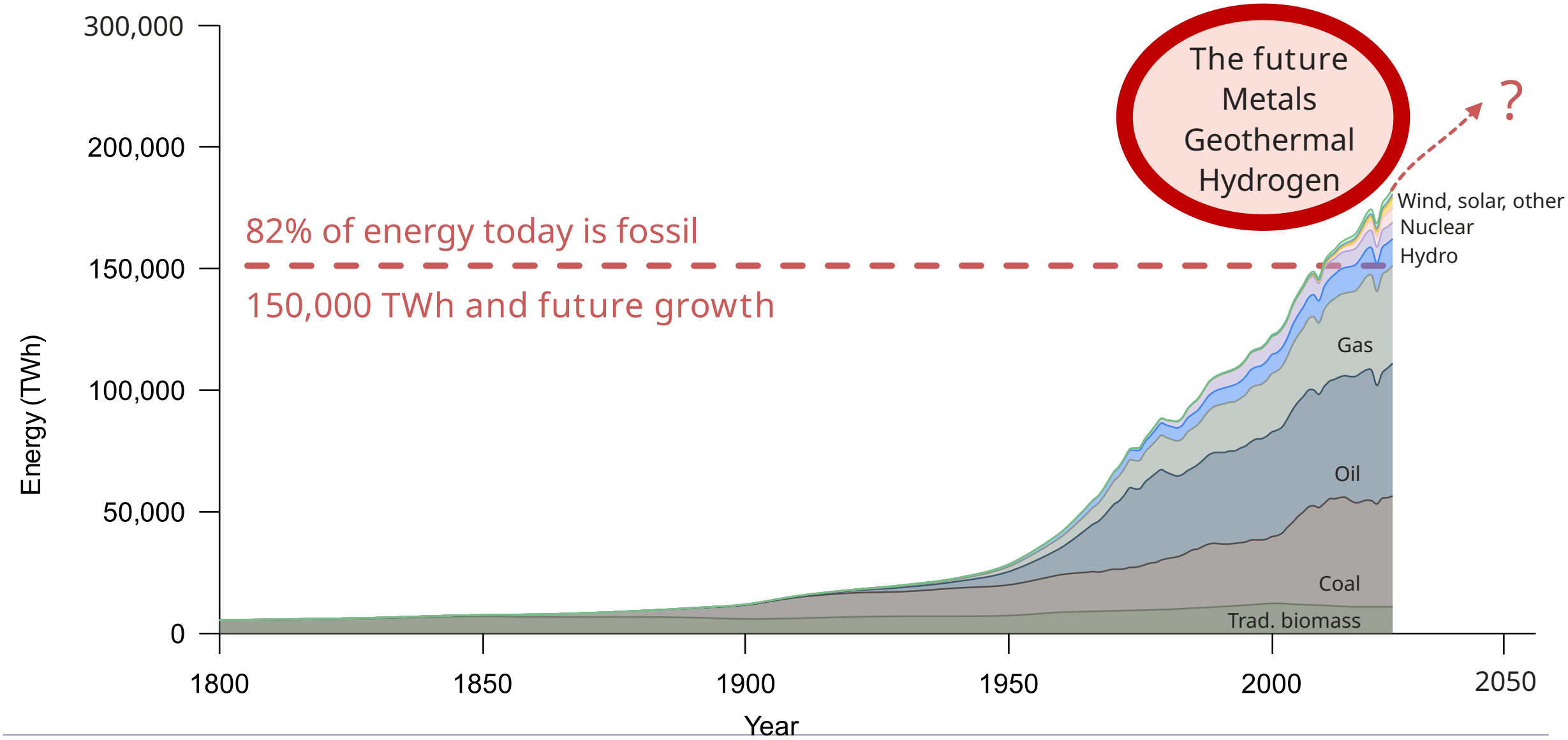
Lipi Acharya | Sam Falzone | Yasheen Jadidi | Eaman Karim | Dien Li | Toni Marechaux | Truong Nguyen | Kate Pitman | Kalena Stovall | Mervin Zhao

Unpictured: Project management, events, and communications support staff

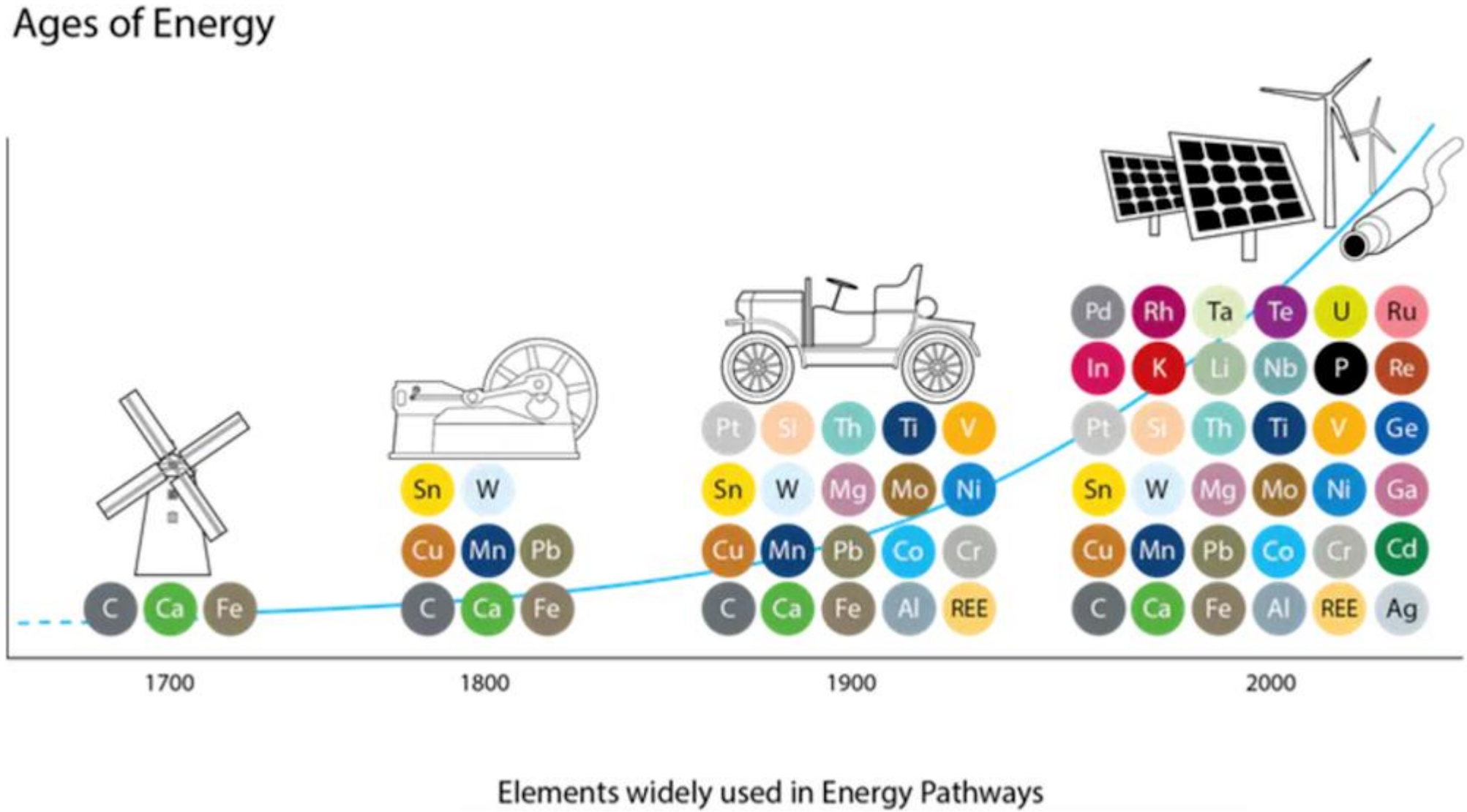
Take a look down to see the future



The past and future of energy is in the subsurface



Technology calls for increasing amounts of energy and metals



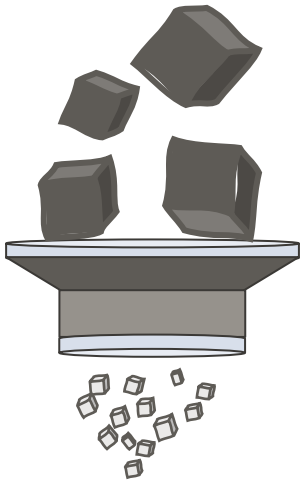
Zepf V, Reller A, Rennie C, Ashfield M & Simmons J, BP (2014): Materials critical to the energy industry

Motivation of the ARPA-E MINER program

- Increasing demand of energy-related minerals
- Decreasing ore grades and increasing energy intensity
- Lack of innovation in the mining industry
- High remediation costs of waste
- Geopolitical risks may interrupt U.S. critical supply chains

Building a community for enhanced mineral recovery

Beneficiation

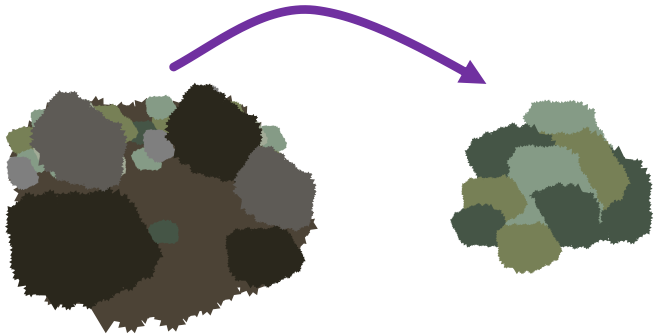


Columbia University

Missouri S&T

University of Kentucky

Extraction



Columbia University

Johns Hopkins University

Virginia Tech

Nevada

Michigan Tech

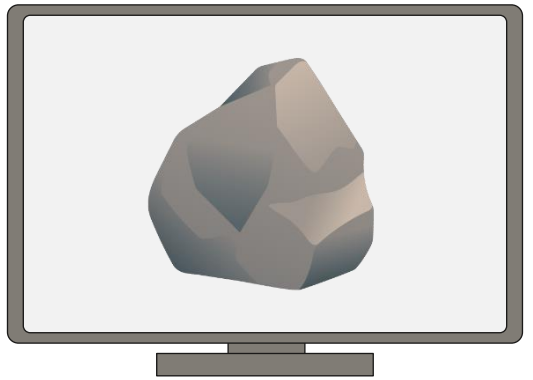
UC Davis University of California

The University of Texas at Austin

PNNL

Phoenix Tailings

Modeling and sensors

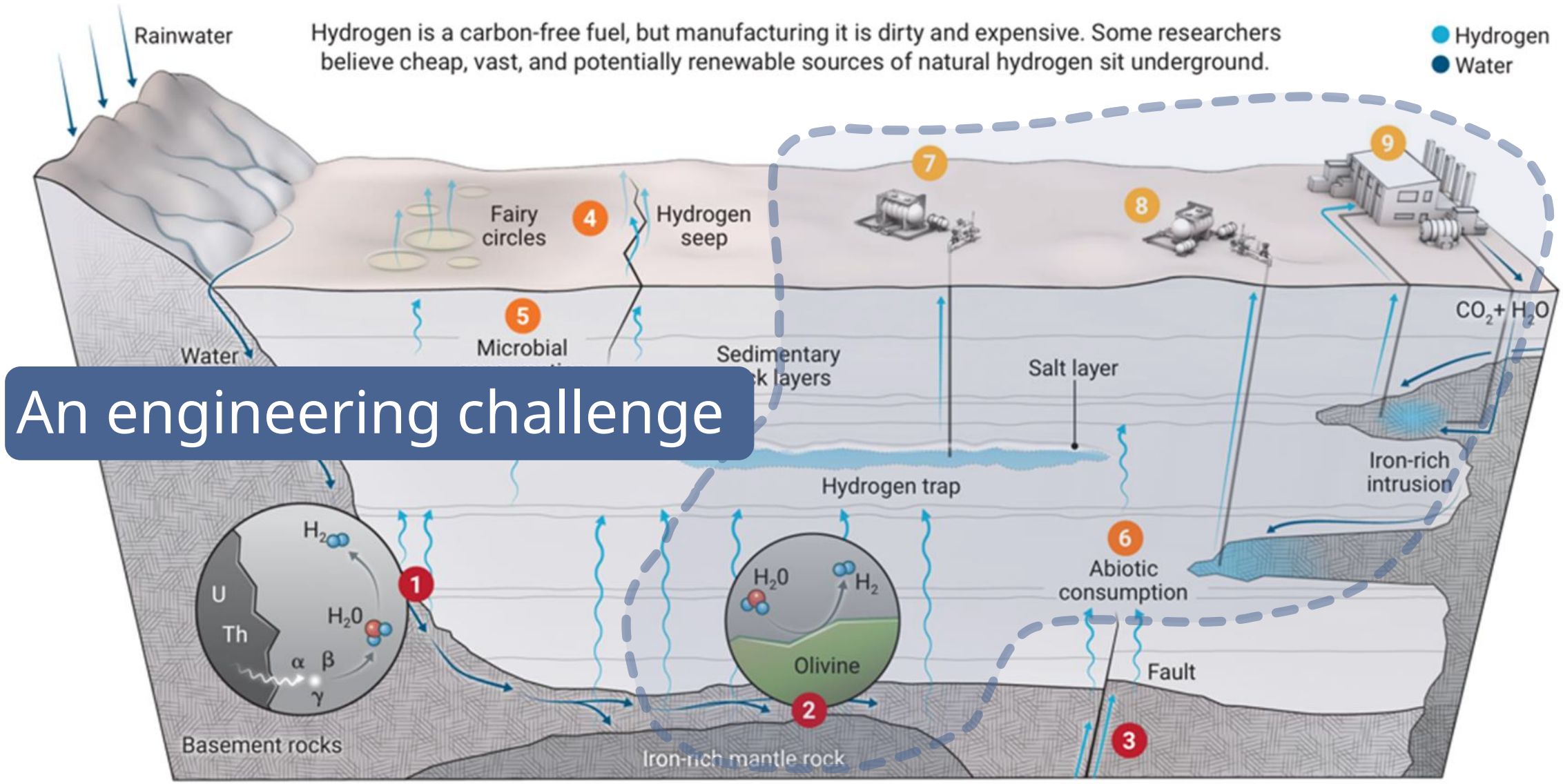


Colorado School of Mines

ARPA-E exploratory program on developing geologic hydrogen

How do we produce it and how do we get it out economically?

The earth continuously produces subsurface H_2 from geological processes



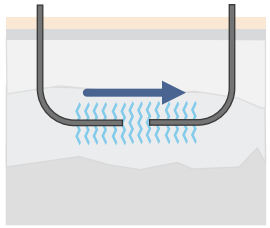
An engineering challenge

E. Hand, *Science* 379, 630–636, (https://doi.org/10.1126/science.adh1477) (Feb. 2023).
G. Ellis, S. E. Gelman, *Science Advances* 10, eado0955, (https://doi.org/10.1126/sciadv.ado0955) (Dec. 2024).

Determining stimulation and engineering parameters

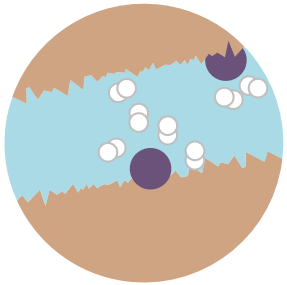
Surface area

NER
Eden
PennState



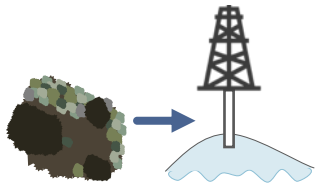
Production and extraction

BERKELEY LAB
TEXAS
The University of Texas at Austin
USC



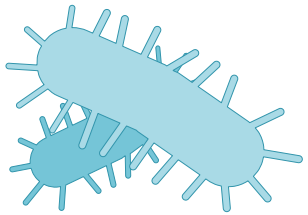
Catalysts

MIT
BERKELEY LAB
TEXAS
The University of Texas at Austin



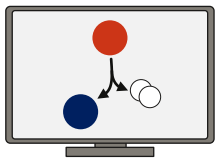
Rock-to-reservoir characterization

NEW MEXICO TECH
SCIENCE • ENGINEERING • RESEARCH UNIVERSITY
A&M



Microbiology

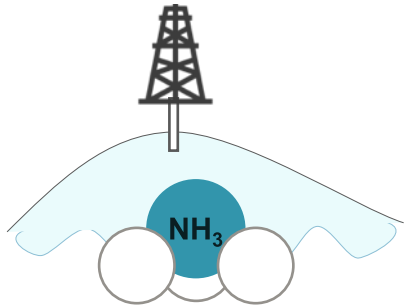
KOLOMA
TEXAS TECH UNIVERSITY



Modeling and monitoring

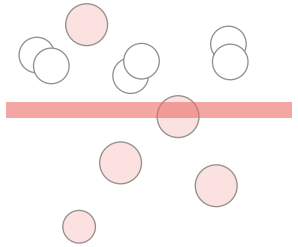
COLORADO SCHOOL OF MINES
39A
Argonne NATIONAL LABORATORY

Other technologies selected in VISION OPEN 2024



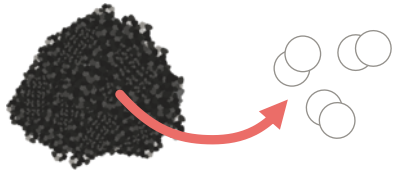
ADDIS ENERGY

Geologic ammonia from wastewater



OSMOSES

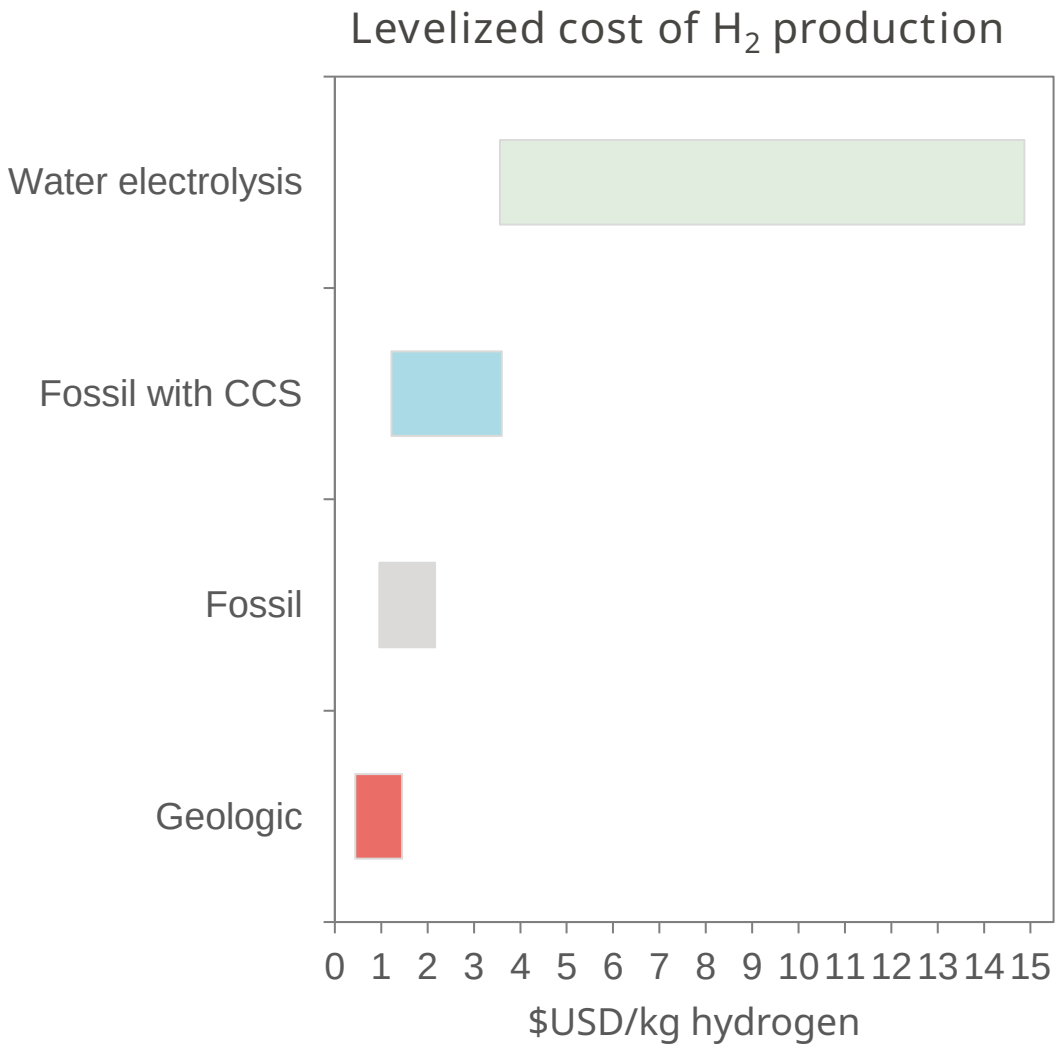
Geologic H_2 powering He separation

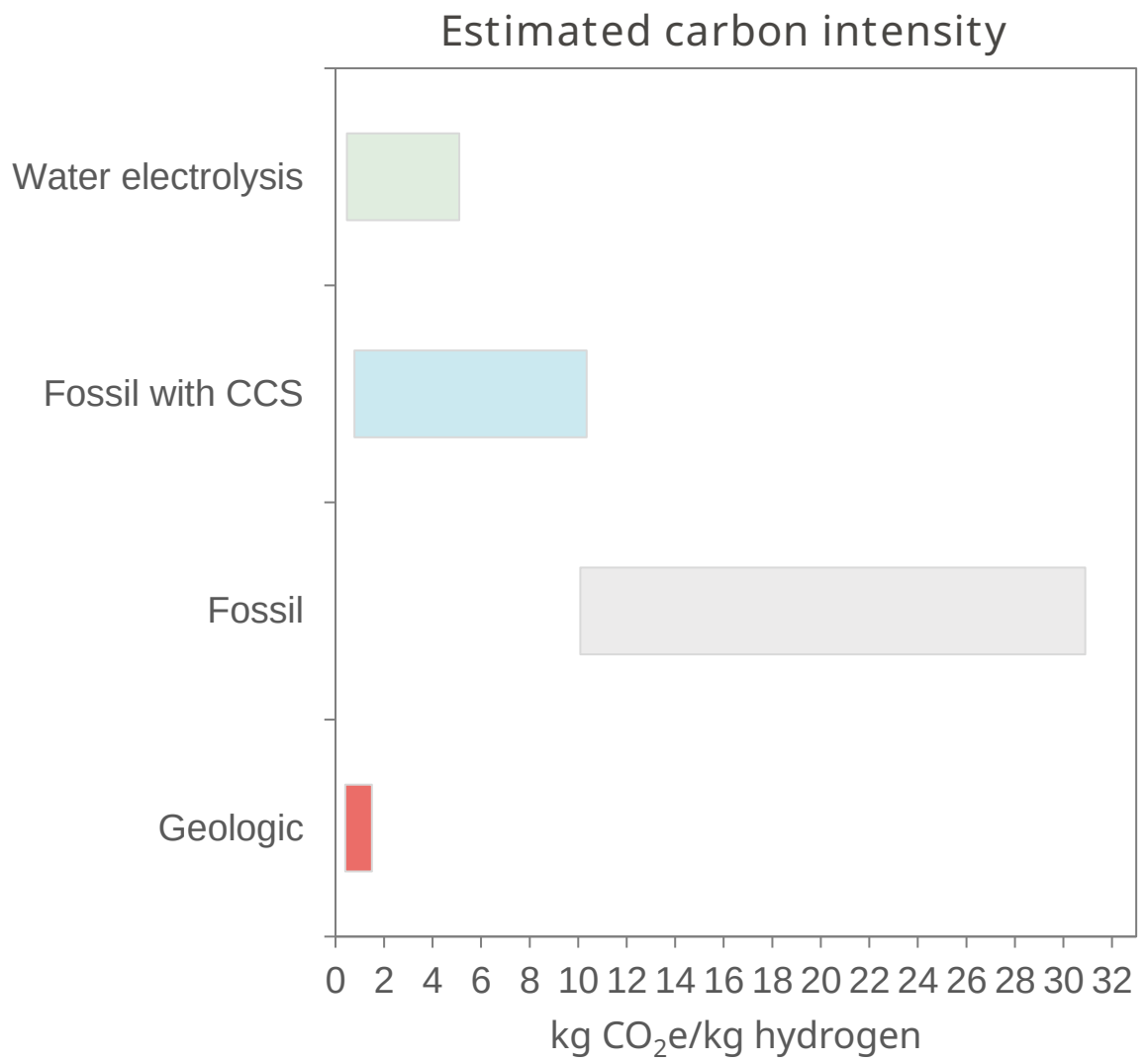


Fortescue™

Processing iron ore tailings for H_2 production and waste iron ore valorization

GeoH$_2$ is potentially the cheapest & cleanest form of H$_2$ production





*Geologic H$_2$ estimates are based on ARPA-E analysis, project input, and this source:
A. Patonia, M. Lambert, N. Lin, M. Shuster, The Oxford Institute for Energy Studies (2024)

Building an entrepreneurial community for subsurface technology

MINER BOOST

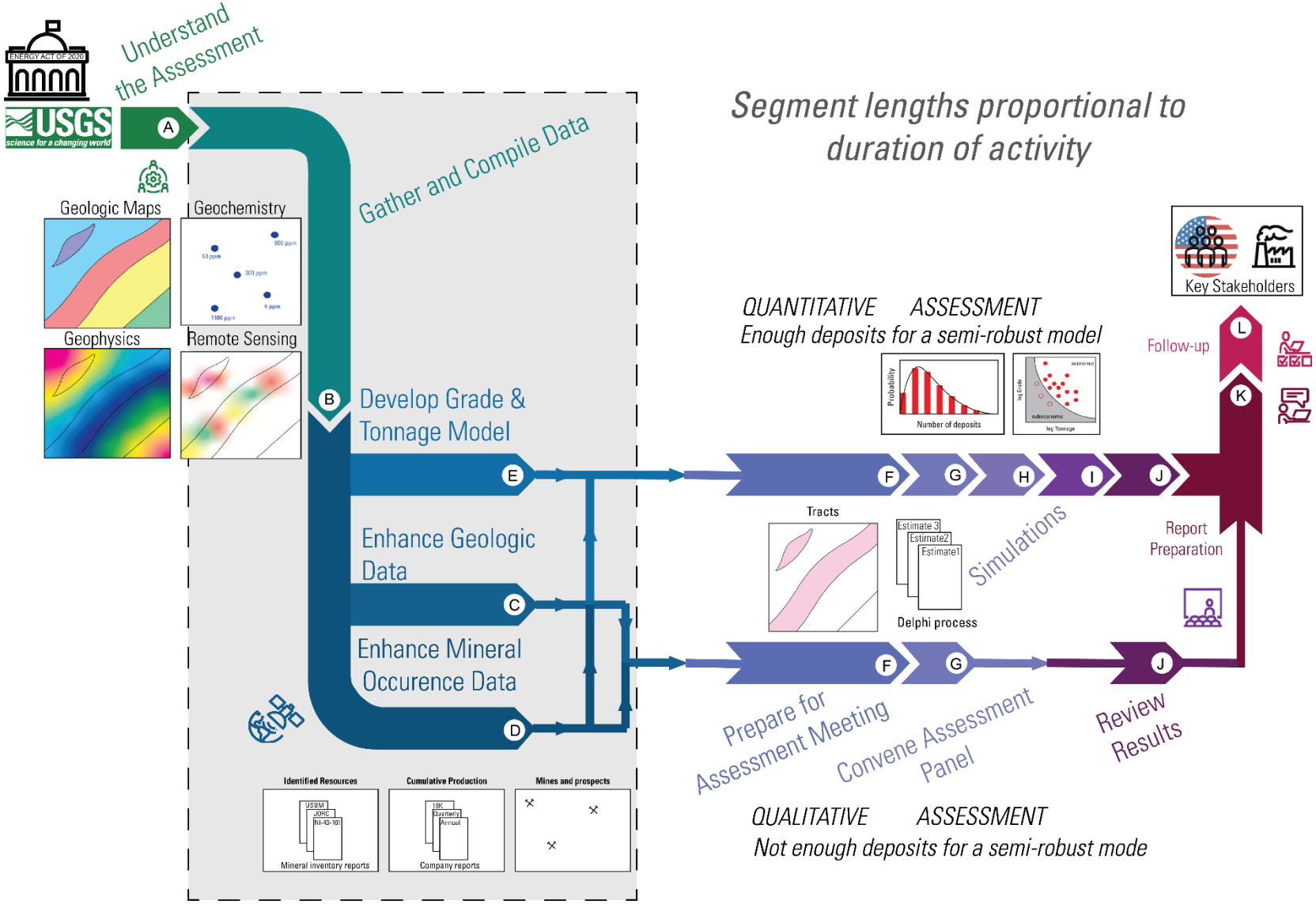
GeoH$_2$ entrepreneurial workshop

CONSCIOUS VENTURE LAB

Activate

ARPA-E IS LEARNING AND NEEDS EVERYONES INPUT

Critical Mineral Assessment with AI Support (CriticalMAAS)



Try to answer:

Where do minerals occur?

What is their nature?

How much do we have?

Provide science to support decision-making

Sensing systems to detect and quantify H_2 emissions (H2SENSE)

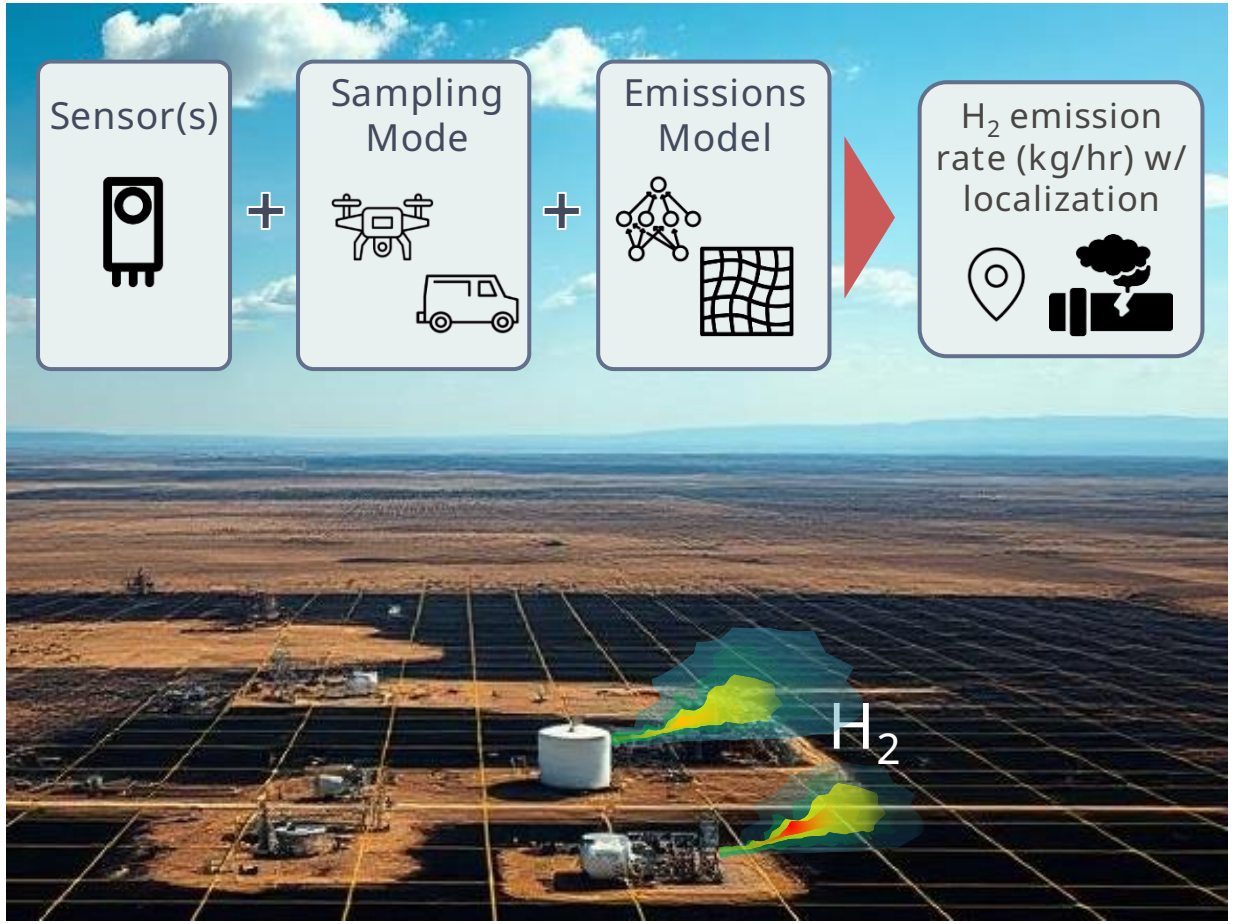
Program Director: Robert Ledoux

Program objectives

- Minimize product loss and support growth of a nascent industry
- Potentially support geo-H_2 resource exploration
- Develop fully integrated systems incorporating sensors, sampling, and advanced modeling
- Enable accurate, economical, and quantified monitoring across H_2 use cases (100×100 m^2)

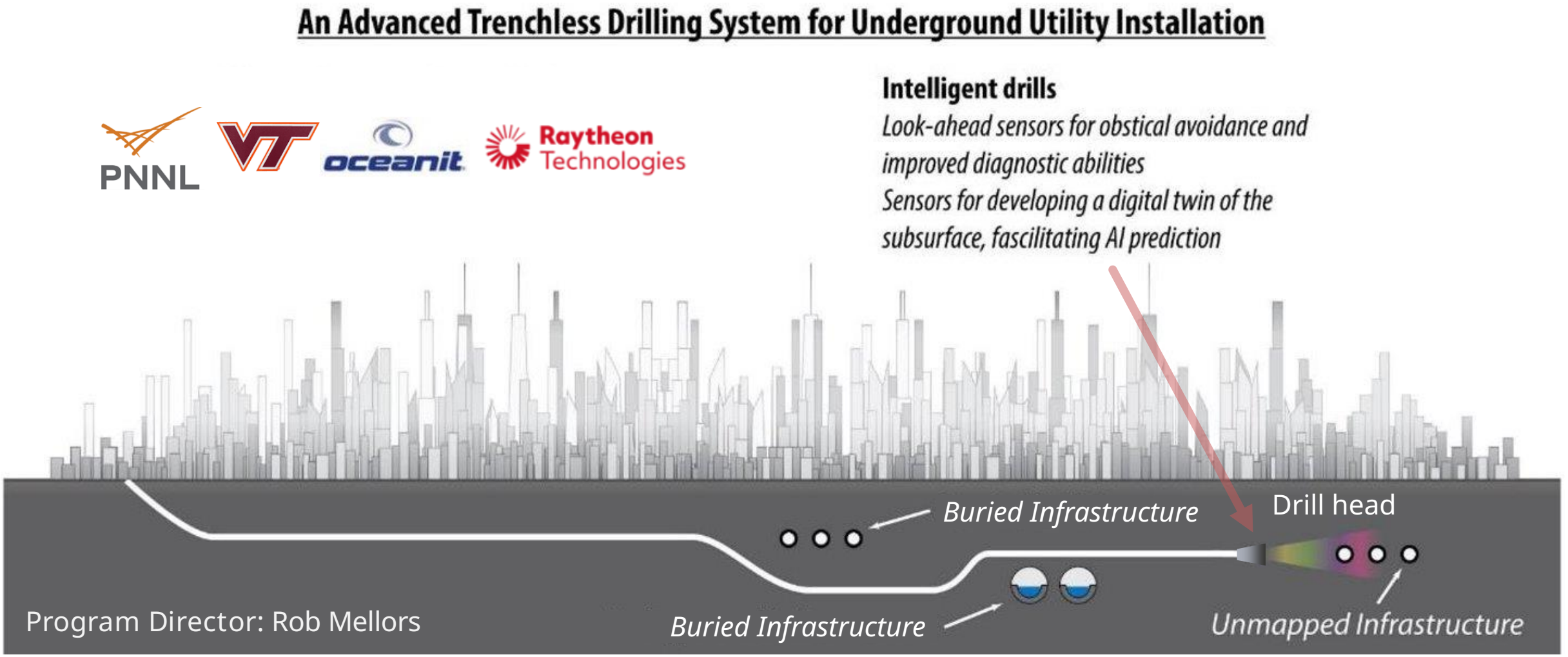
2024, $18 Million, 9 Projects

GE VERNOVA
WISCONSIN UNIVERSITY OF WISCONSIN–MADISON
PRINCETON UNIVERSITY
COLORADO STATE UNIVERSITY
Serinus LABS
Aerodyne Research
NATIONAL ENERGY TECHNOLOGY LABORATORY
Northeastern University
2wiTech Solutions



High speed undergrounding for grid overhaul (GOPHURRS)

Grid Overhaul with Proactive, High-speed Undergrounding for Reliability, Resilience, and Security



Program Director: Rob Mellors

The vision of SUPERHOT

Make superhot geothermal a widely available and scalable source of clean U.S. baseload power by 2045

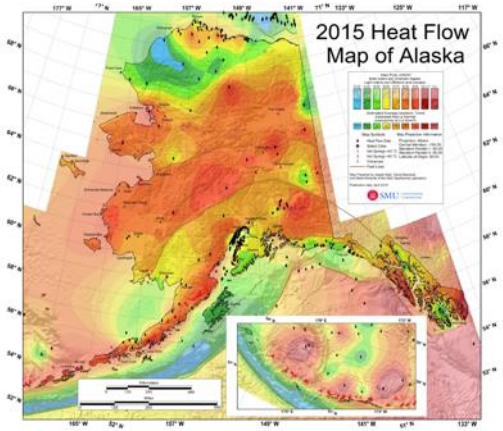
The challenge: Produce power from ≥400°C geothermal resources >15 years. Currently <200°C due to equipment and well limitations.

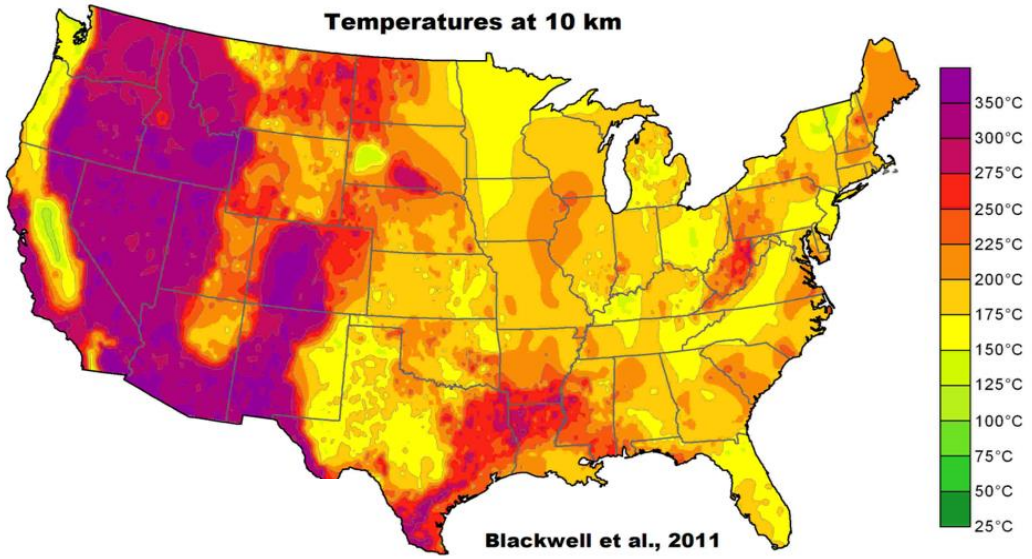
Disruptive: >3-4× well productivity, lower electricity costs

Impact:

- 10's of GW of power in the next 20 years
- Ensure US lead in geothermal technology
- Leverage oil and gas expertise and workforce

Hawaii



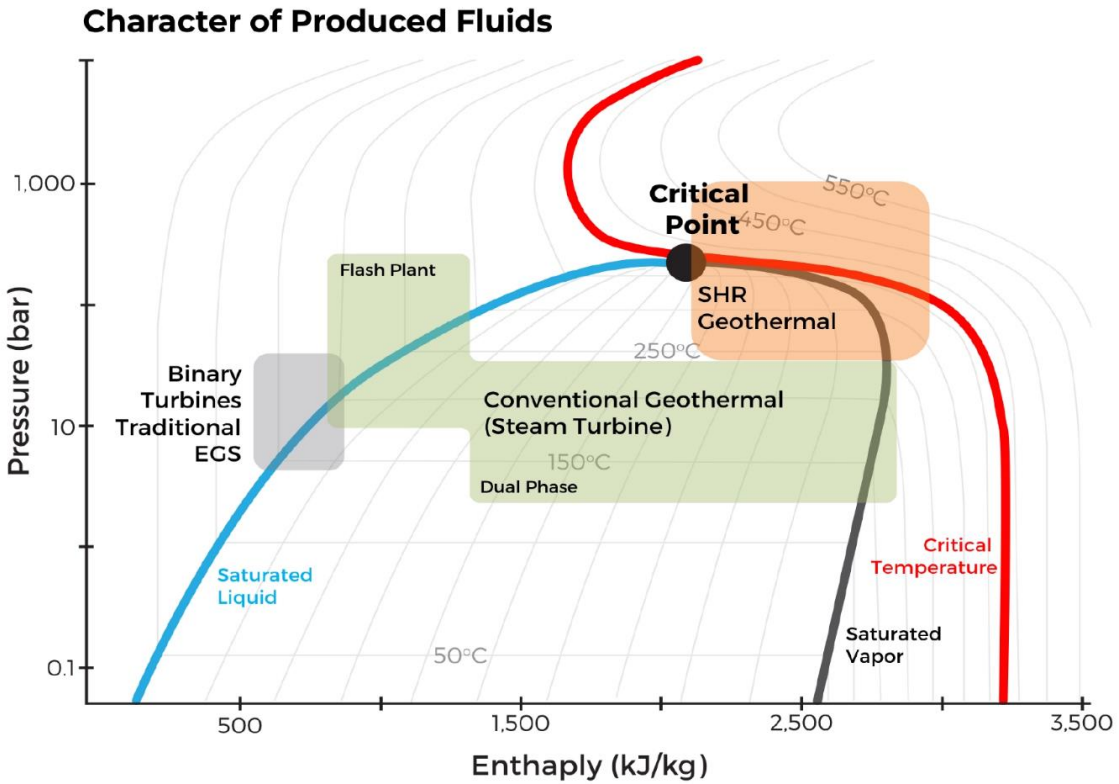


Program Director: Rob Mellors

https://www.smu.edu/dedman/academics/departments/earth-sciences/research/geothermallab/datamaps/geothermalmapofnorthamerica

Wells and materials for superhot geothermal (SUPERHOT)

Stimulate Utilization of Plentiful Energy in Rocks through High-temperature Original Technologies



Program focus on new well designs and technology to extract heat from superhot reservoirs

- Well construction and survivability (>400°C for 15+ years)
- Fracture reservoirs in superhot/supercritical reservoirs
- Develop high temp high pressure analytical facilities for superhot/supercritical testing conditions

Program Director: Rob Mellors

New program development: Next-generation stimulation and recovery technologies

GOAL: To substantially increase per-well recovery efficiency while improving water management.

Shale, Tight Oil &Gas

Enhanced Geothermal Systems

In-Situ Recovery of Minerals & Metals

COMMON CHALLENGES

- Low permeability
- Limited Fluid–reservoir contact area
- Poor resource mobilization
- Water demand & disposal

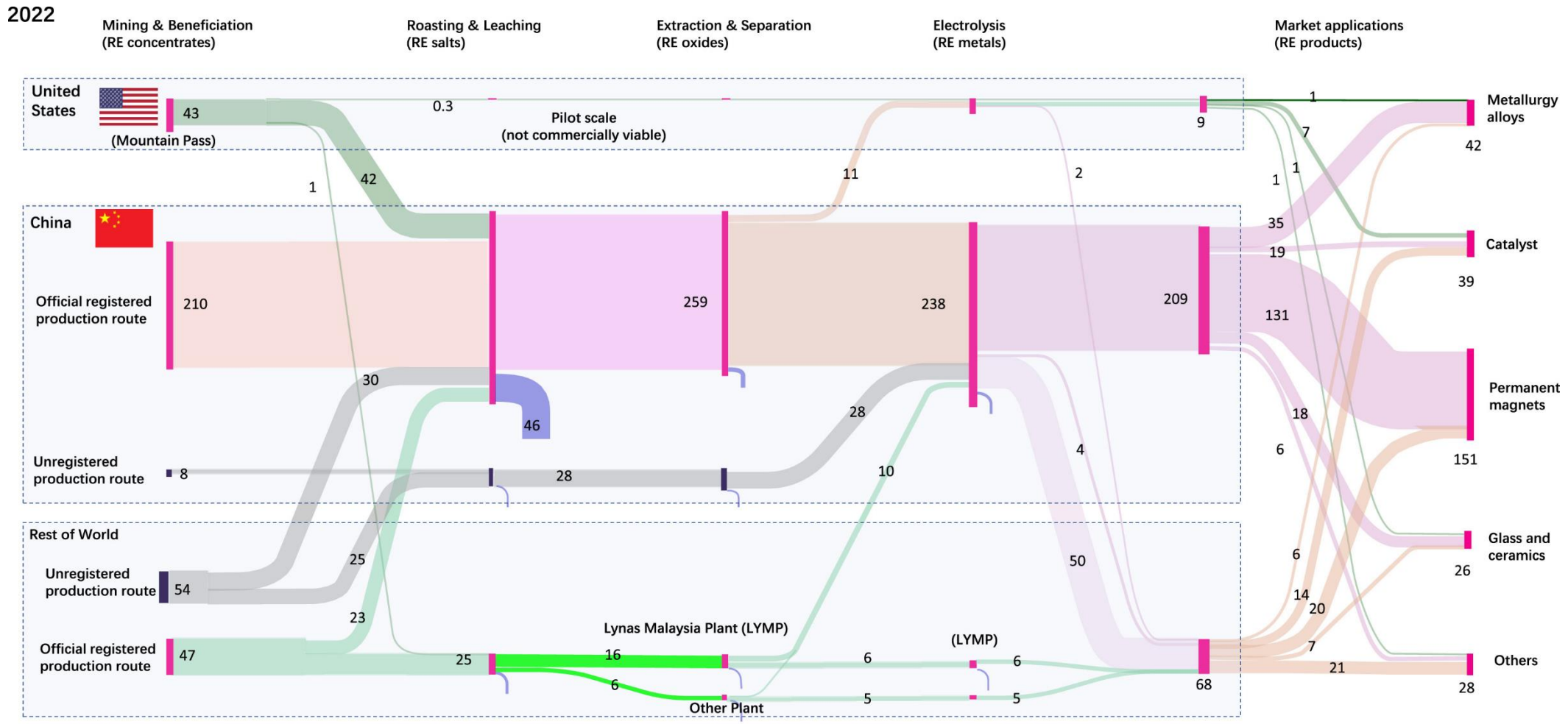
Program Director: Jo Sharma

You are working on timely and significant research

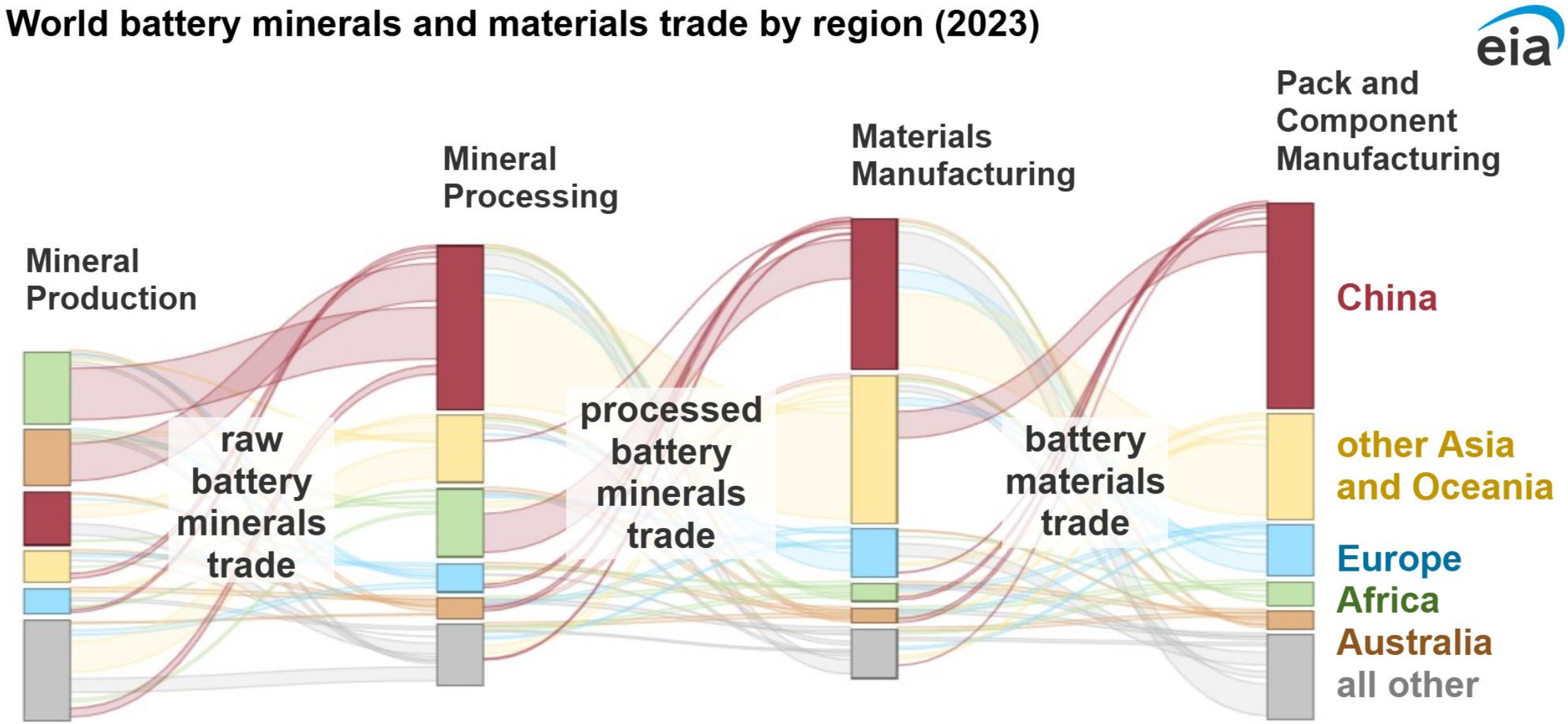
China's Halt of Critical Minerals Poses Risk for U.S. Military Programs

US-China Trade War: Can the US Beat China's Critical Minerals Grip?

Trump strategy threatens critical mineral supplies for clean power



You are working on timely and significant research



Executive Orders

Establishing the National Energy Dominance Council

UNLEASHING AMERICA'S OFFSHORE CRITICAL MINERALS AND RESOURCES

Immediate Measures to Increase American Mineral Production

ENSURING NATIONAL SECURITY AND ECONOMIC RESILIENCE THROUGH SECTION 232 ACTIONS ON PROCESSED CRITICAL MINERALS AND DERIVATIVE PRODUCTS

Our national and economic security are now acutely threatened by our reliance upon hostile foreign powers' mineral production. It is imperative for our national security that the United States take immediate action to facilitate domestic mineral production to the maximum possible extent.

The U.S. future needs to rely on strategic advantages

The U.S. has a strategic advantage in oil and gas technology infrastructure and workforce, as well as robust demand through defense needs

Utilizing these advantages is the only way to secure U.S. technology leadership

Improving subsurface technologies improves our future

Subsurface technologies will be vital for future metals and energy

How will YOU make subsurface technologies better: cheaper, safer, and cleaner?