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OptiRock GROUP

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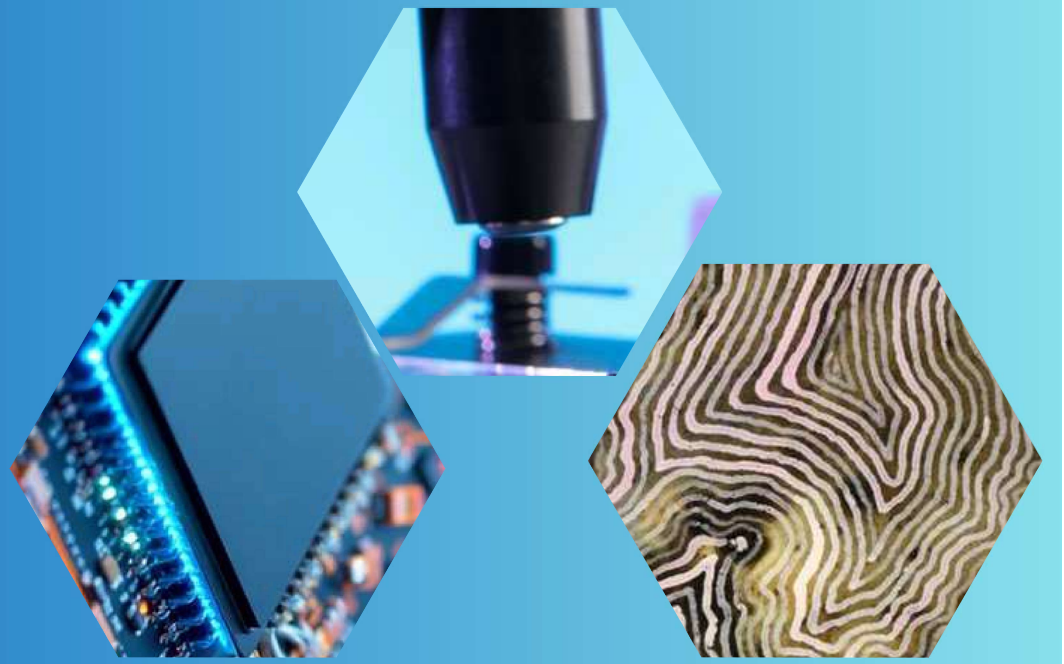
STIMULATED GEOLOGIC HYDROGEN

An integrated and collaborative solution



GEOLOGIC HYDROGEN

Our team started with one

big question:

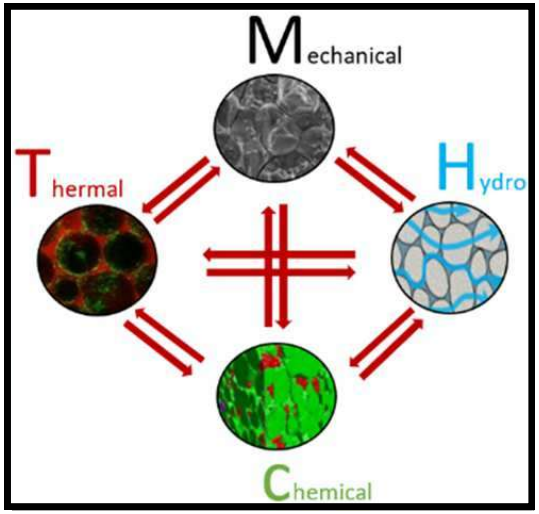
Next-generation energy demands require next-generation energy solutions.
Geologic hydrogen is among the top cited energy sources which is capable of meeting increased energy demands while remaining carbon neutral.

Geologic hydrogen can come from many sources, and one of the most common is from the reaction of rocks rich in olivine, an ultra-mafic mineral, with water. This natural reaction produces serpentinite, and as a by-product, **natural hydrogen.**

Serpentinization reactions are always happening in the earth's crust, but the natural hydrogen is released over millions of years. Our team started with **one big question:**
can a natural process be amplified to provide the world with a previously untapped source of clean energy?

The process of hydrogen generation from serpentinization is complex, and arises from the interaction of thermal, hydro, mechanical, and chemical (THMC) processes. If we are going to amplify the natural serpentinization process to liberate hydrogen in human time-scales, we will need to understand how these processes fit together. Can we create a chain reaction in serpentinization by leveraging the natural THMC coupling of this complex system? Is it possible that an accelerated mechanical promotion (AMP) front can be formed by fine tuning these conditions in the subsurface?

This multidisciplinary effort requires experts from a wide range of fields. New England Research (NER), building upon years of expertise in laboratory testing and simulation for sub-surface applications, has teamed with Missouri S&T and OptiRock Group to tackle this project.



AMP OF SERPENTINIZATION FOR HYDROGEN PRODUCTION

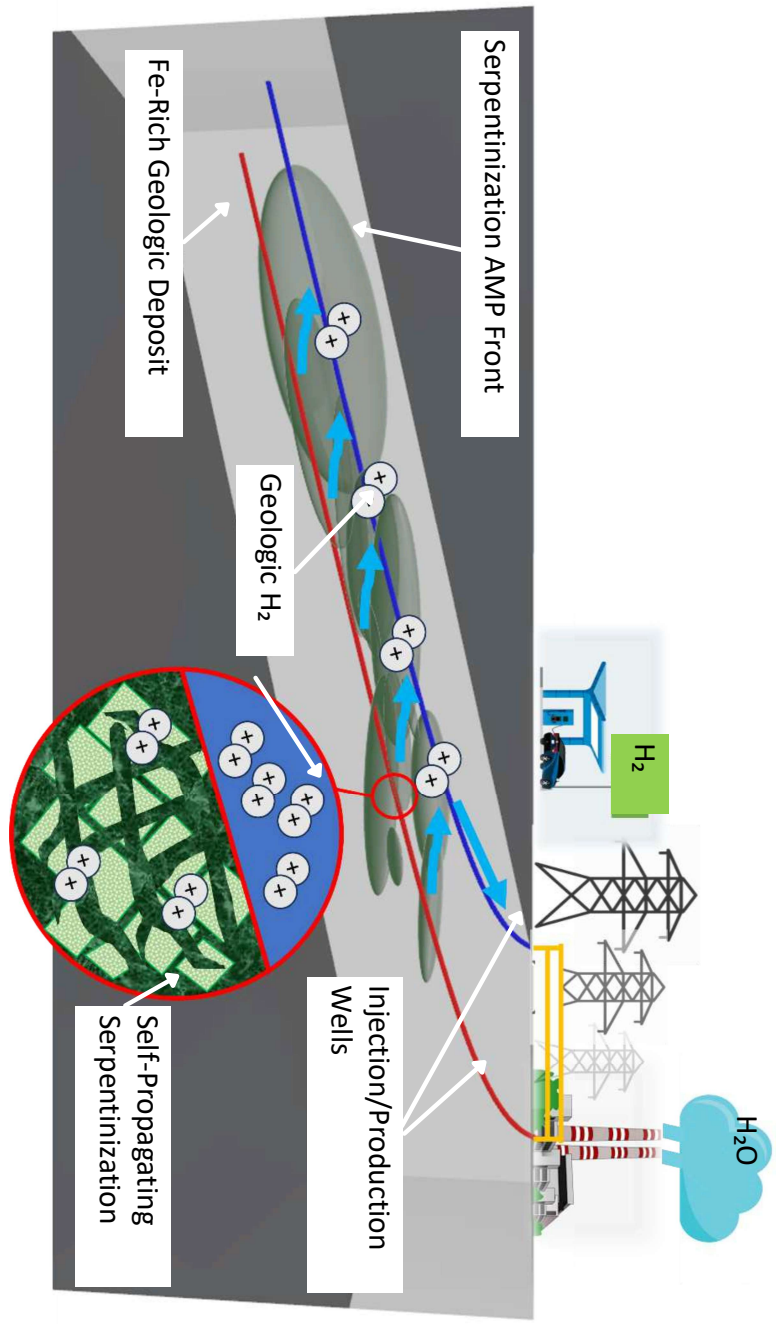
Hydrogen production from serpentinization is a complex thermo-hydro-mechanical-chemical (THMC) process that occurs when mafic and ultramafic rocks react with water at specific pressure-temperature conditions.

The reaction rate depends heavily on the available surface area in which mafic/ultramafic (i.e., Fe-Mg rich) minerals such as olivine are exposed to water.

On a reservoir scale, high amounts of surface area are energy-intensive to generate and maintain, and technologies for reservoir stimulation developed for oil and gas production fall short of producing meaningful surface exposure in dense rock formations.

Accelerated Mechanical Promotion (AMP) is an environmentally safe stimulation process by which a front of volumetrically expanding mineralization produces new fluid pathways that induce further mineralization, thus expanding a micro-fracture cloud and resulting in exponential surface area production to facilitate new reactions. **We propose that if properly engineered, this process can continue with minimal energy input after initiation.**

Ultimately, we aim to identify the unique THMC conditions that can result in AMP which can be achieved at field scales and result in economically beneficial hydrogen production.



The serpentinization AMP concept for stimulated geologic hydrogen production.

Serpentinization AMP

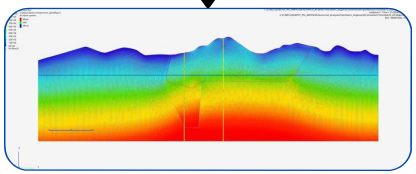
Geoengineering for a clean energy future.

ARPA-E AWARDEE

PROJECT WORKFLOW

Identification of potential stimulated geologic hydrogen targets

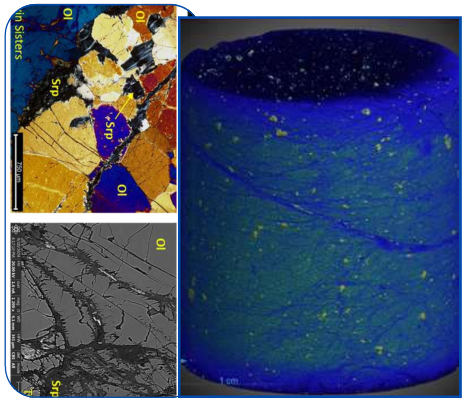
Collecting samples of ultramafic rocks with varying compositions and degrees of alternation from key field locations



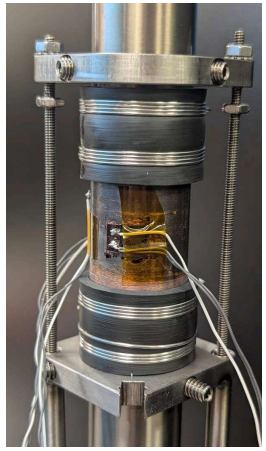
Advanced specimen characterization to determine pre-test serpentinization levels including:

- **Petrography**
- **SEM**
- **Micro CT Scanning**

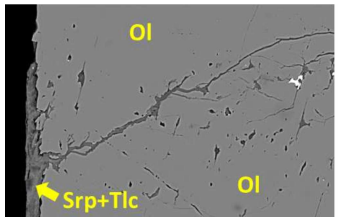
Analysis of available stress and temperature conditions at field locations



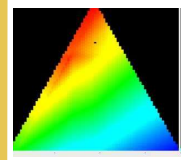
Laboratory testing at temperature and pressure with reactive flow. Advanced sensors, protocols, and rapid prototyping to test new ideas. Testing workflows for characterization and optimization.



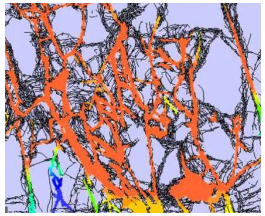
Post-test specimen characterization to identify induced serpentinization



Identification of optimal conditions for serpentinization AMP and <u>stimulated hydrogen production</u>



Digitization of specimen microstructures and numerical simulation/parametric studies



Serpentinization AMP

Geoengineering for a clean energy future.

ARPA-E AWARDEE

MEET THE TEAM

A project of this scale requires multidisciplinary collaboration. The $GeoH_2$ research team assembled by NER is made up of researchers and engineers from across industries and academia.

Greg Boitnott, Ph.D., New England Research

“By leveraging our experience in in geomechanics testing for oil and gas, and geothermal reservoir engineering, we are working to develop new protocols for quantifying the hydrogen potential of serpentinizing rocks”

NER

Steven Hender, New England Research

"Testing at these temperatures and pressures with reactive flow are the kinds of measurements projects we thrive on at NER."

Uno Mutlu, Ph.D., New England Research

“THMC coupled processes are complex by their very nature. By combining a wide range of numerical techniques, we’re starting to crack the code on serpentinization AMP and identifying the conditions for optimizing hydrogen production”

Taghi Sherizadeh, Ph.D., Missouri S&T

“We are going back to basics on this one, with a decade of experience in oil and gas, mining, and experimental geomechanics, were answering some of this generation’s biggest questions”

MISSOURI S&T™

Bolorchimeg Nanzad Tunnell, Ph.D., Missouri S&T

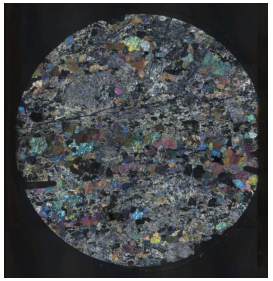
“This project is happening at every level, from field scale to an analysis of micro-textures with our micro-CT scanner. When you’re looking at a problem this big, sometimes, you need to start small ”

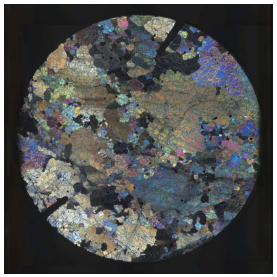
Peter Connolly, Ph.D., Missouri S&T

“We’ve really had to integrate a lot of diverse processes here. To me, that’s the exciting part. One day we’re looking at the stresses under a mountain range, and the next we’re considering their impact at the scale of mineral grains ”

Samuel Nowak, Ph.D., Co-Founder, OptiRock Group

“We started this project in the field, collecting samples of unaltered rocks for testing in the lab. Now, we’re working with industry leaders to identify how they could produce hydrogen in their own properties ”





OptiRock GROUP

Jessica Domino, Ph.D., OptiRock Group Geochemistry

“It’s always exciting to take a deeper look at a problem from different perspectives, that’s where I see our leverage to a problem of this scale.”

Let's tackle your next challenge together...

Numerical Applications

- THMC Coupling of numerical simulations
- Crack propagation modelling
- Field scale/regional stress modelling
- Calibration of simulations with physical observations

Laboratory Scale

- THMC Coupled laboratory systems for testing of Geomaterials
- Advanced specimen monitoring at high pressure and temperatures
- Superhot testing of geomaterials for geothermal and deep subsurface applications
- Advanced micro scale specimen characterization

Field Scale

- In Situ stress analysis and regional geologic characterization
- Assessment of economic potential for field sites
- Mining and tunneling engineering
- Field Scale monitoring for geomechanics applications

H_2 Accelerated

Contact us today!

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