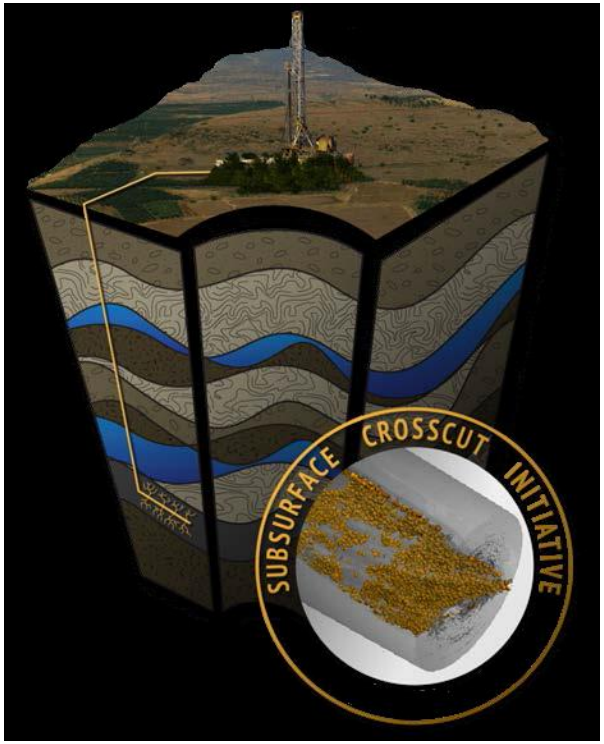
Welcome!

AGU Town Hall Meeting
TH15E
6:15-7:15

DOE Crosscutting Subsurface Initiative: Adaptive Control of Subsurface Fractures and Flow



For More Information

Website:

http://energy.gov/subsurface-tech-team

AGU booths:

In Exhibit Hall:

- Lawrence Berkeley National Laboratory (#2309)
- Oak Ridge National Laboratory (#2813)
- Sandia National Laboratories (#2819)

Student/Career Center Lounge, Moscone South:

- Los Alamos National Laboratory (Room 101)

Register at both locations to receive email updates

Subsurface Fact Sheet

ENERGY Office of the Under Secretary for Science and Energy

Energy Department Subsurface Crosscut

Addressing Common Subsurface Challenges

The ability to master the subsurface continues to elude researchers and practitioners working on a variety of energy production and storage applications. The DOE is implementing a new collaborative model to tackle this "energy grand challenge" through a coordinated RD&D strategy. Common challenges faced by the participating offices include:

1. **Discover, Characterize, and Predict**
   - accurately characterizing the subsurface using integrated geophysical and geochemical technologies
   - Quantitatively inferring subsurface evolution under current and future engineered conditions
   - Finding viable, low-risk resources
2. **Access**
   - safe, cost-effective reservoir integrity
3. **Engineer**
   - Creating/constructing desired subsurface conditions in challenging high-pressure/high-temperature environments
4. **Sustain**
   - maintaining optimal subsurface conditions over multi-decadal or longer time frames through complex system evolution
5. **Monitor**
   - improving observational methods to advance understanding of multi-scale complexities through system lifetimes

The SubTER technical team identifies and facilitates crosscutting RD&D and policy activities for DOE, to enable programs with common technical challenges to work together toward solutions. The SubTER crosscut reports to the Under Secretary for Science and Energy and leverages program budget priorities to better plan for investment and assistance. While each of the offices brings new activities to the table, the sector benefits as a whole from crosscutting solutions. Partnerships include Departmental programs and offices, labs, academia, and industry, as well as synergies across federal agencies.

Subsurface Technology and Engineering Research, Development, and Demonstration (SubTER) Crosscut

Subsurface energy sources satisfy over 80% of total U.S. energy needs. Finding and effectively exploiting these resources while mitigating impacts of their use constitute major technical and socio-political challenges. Still, the opportunities are vast. Next generation advances in subsurface technologies will enable increases in domestic natural gas supplies, as well as 100+ GWe of clean, renewable geothermal energy. The subsurface provides hundreds of years of safe storage capacity for carbon dioxide (CO_2), and opportunities for environmentally responsible management and disposal of hazardous materials and other energy waste streams. The subsurface can also serve as a reservoir for energy storage for power produced from intermittent generation sources. These opportunities have immediate connection to societal needs and administration priorities. Clean energy deployment and CO_2 storage are critical components of the President's Climate Action Plan, necessary to meet the 2050 greenhouse gas (GHG) emissions reduction target. Increasing domestic energy supply from greater hydrocarbon resource recovery, in a sustainable and environmentally sound manner, are also Administration goals that enhance national security and fuel economic growth.

Who's Involved?

Representing the geosciences, research, modeling, technology development, policy, and stakeholders, the participating program offices include:

- Fossil Energy-Oil and Gas
- Fossil Energy-CO_2 Storage
- EERE-Geothermal Technologies Office
- Nuclear Energy
- Environmental Management
- Office of Science
- ARPA-E
- Office of Electricity
- Energy Policy & Systems Analysis
- Congressional & Intergovernmental Affairs
- Energy Information Administration

DOE Subsurface Crosscut Background:

- Marianne Walck - Sandia National Laboratories

Comments:

- Mark Zoback – Stanford University
- Sally Benson – Stanford University

Discussion:

- All!

DOE Subsurface Technology and Engineering RD&D (SubTER) Overview

Offices of . . .

Energy Efficiency and Renewable Energy
Fossil Energy
Nuclear Energy
Environmental Management
Science
Energy Policy and Systems Analysis
Electricity Delivery and Energy Reliability
Congressional and International Affairs
Energy Information Administration
ARPA-E

AGU Town Hall Meeting

San Francisco, California

December 15, 2014

energy.gov/subsurface-tech-team

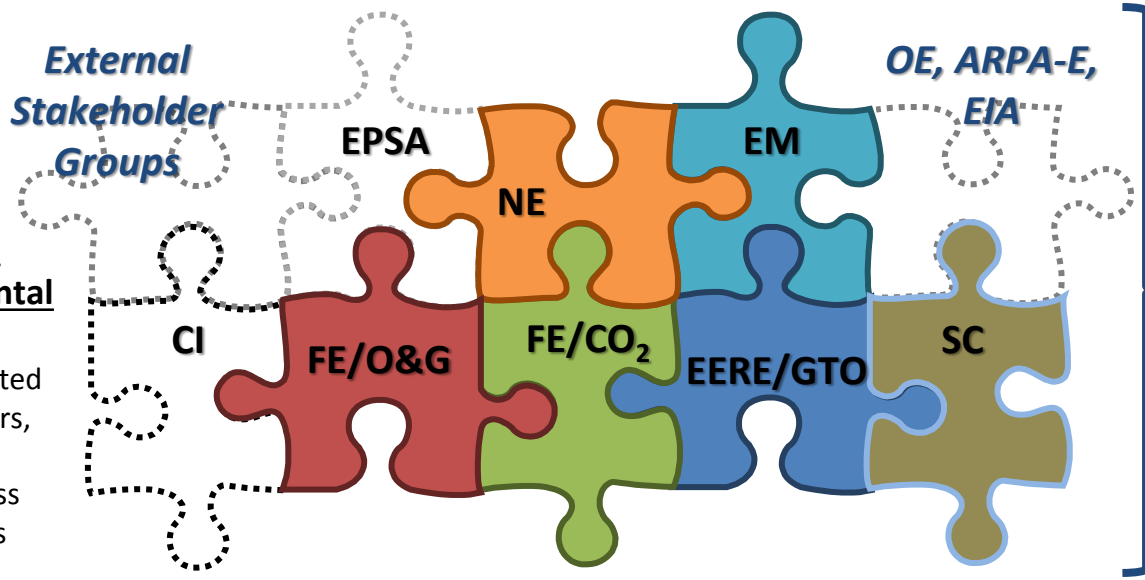
Overview of Program Roles

Energy Policy & Systems Analysis
- Advisement: Secretary of Energy
- Policy: low-carbon and secure energy economy
- Technical assistance: States and local entities

Nuclear Energy
- Policy and technology: disposition of used nuclear fuel and waste
- R&D: deep borehole disposal concept

Environmental Management
- Modeling and tools: subsurface evaluation and characterization
- Cleanup: nuclear weapons legacy

Congressional & Inter-governmental Affairs
- Interactions: elected officials, regulators, and stakeholders
- Information access for change agents



SubTER Tech Team
- Encompasses relevant offices
- Reports to Under Secretary for Energy and Science
- Identifies and facilitates crosscutting subsurface R&D and policy priorities for DOE
- Develops collaborative spend plan and funding scenarios

Fossil Energy/Oil & Gas
- R&D and access: clean, affordable traditional fuel sources
- R&D: drilling, well construction and integrity, and hydraulic fracturing technologies

Fossil Energy/Carbon Storage
- Policy and technology: challenges of CO_2 storage to inform regulators, industry, and the public
- R&D: CO_2 offshore and onshore storage

Energy Efficiency & Renewable Energy/ Geothermal Technologies Office
- R&D: locate, access, and develop geothermal resources
- R&D: access, create, and sustain enhanced geothermal systems (EGS)

Science
- Basic research: geology, geophysics, and biogeochemistry
- Expertise: subsurface chemistry, complex fluid flow

Common Subsurface Energy Challenges

Discovering, Characterizing, and Predicting

Efficiently and accurately locate target geophysical and geochemical responses, finding more viable and low-risk resource, and quantitatively infer their evolution under future engineered conditions

Accessing

Safe and cost-effective drilling, with reservoir integrity

Engineering

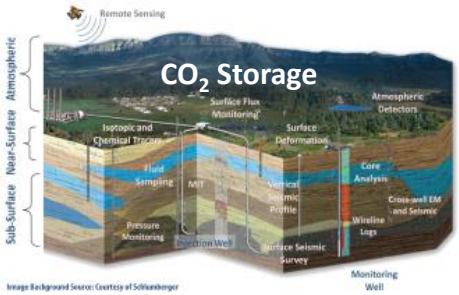
Create/construct desired subsurface conditions in challenging high-pressure/high-temperature environments

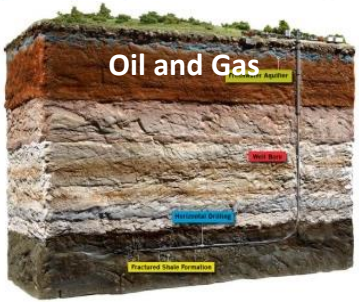
Sustaining

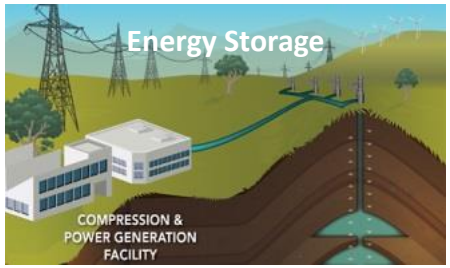
Maintain optimal subsurface conditions over multi-decadal or longer time frames through complex system evolution

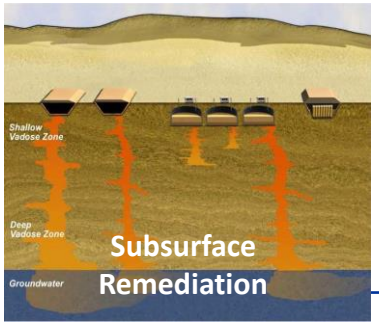
Monitoring

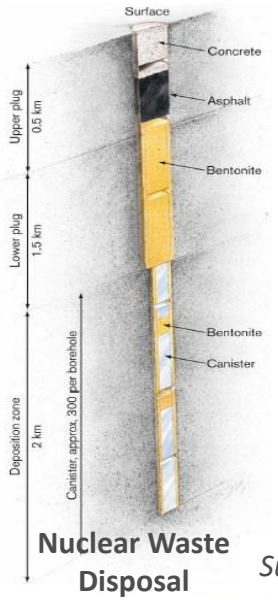
Improve observational methods and advance understanding of multi-scale complexities through system lifetimes







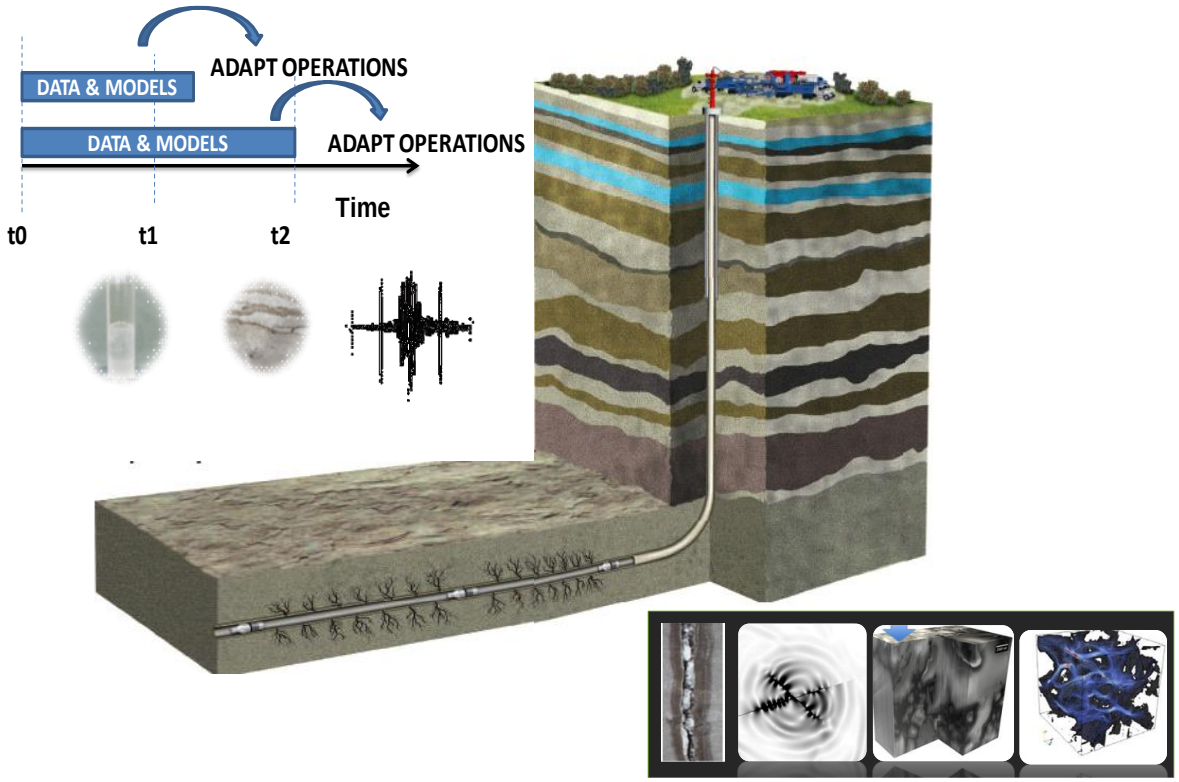




“Adaptive Control” of subsurface fractures and flow

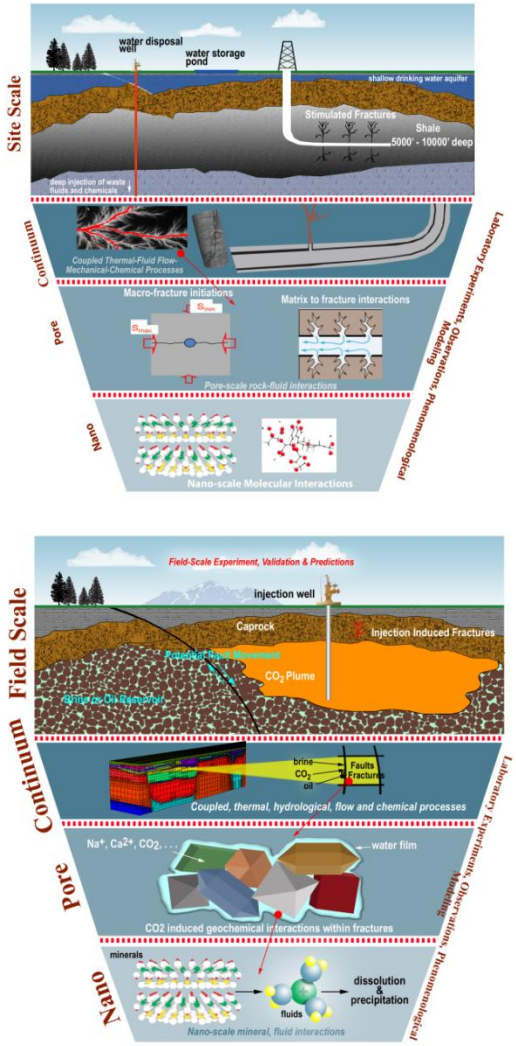
Ability to adaptively manipulate - with confidence and rapidly- subsurface fracture length, aperture, branching, connectivity and associated reactions and fluid flow.

A “Grand Challenge”



General Technical Baseline: State of Knowledge & Practice

- Reservoir stress distribution and material properties are highly heterogeneous and largely unknown
- Mechanistic understanding of multi-scale processes that influence stress distribution and thus fracture formation and flow is lacking - limits both production and subsurface storage
- Industry is developing approaches to improve fracture creation, commonly guided by empirical field evidence. Industry not attempting 'real time' control
- Significant public concern and uncertainty associated with environmental risks



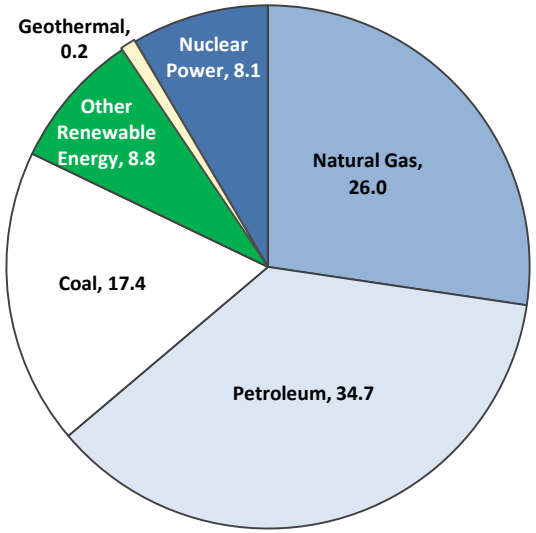
Today we cannot accurately image, predict, or control fractures with confidence or in real-time.

Subsurface Control for a Safe and Effective Energy Future

Adaptive Control of Subsurface Fractures and Fluid Flow

Intelligent Wellbore Systems	Subsurface Stress & Induced Seismicity	Permeability Manipulation	New Subsurface Signals

Energy Field Observatories



Primary Energy Use by Source, 2012
Quadrillion Btu [Total U.S. = 95.1 Quadrillion Btu]

ENERGY PRODUCTION

- Increase U. S. electrical production from geothermal reservoirs
- Increase U.S. unconventional oil and natural gas for multiple uses

ECONOMIC & SOCIAL BENEFITS

- Retain U. S. leadership
- Increased public confidence
- Increase revenues (taxes and royalty) to Federal, State, and local governments

PROTECT THE ENVIRONMENT

- President's Climate Action Plan: Safely store CO_2 to meet GHG emissions reduction targets
- Safe storage/disposal of nuclear waste
- Reduced risk of induced seismicity
- Protect drinking water resources

ENERGY SECURITY

- Increased recovery factors from tight formations can vastly increase the longevity of US energy security

What Is Unique About the SubTER Initiative?

- Facilitates innovation to address **climate change** and reduce greenhouse gas emissions
  - Safe storage of CO_2
  - Increased deployment of renewable energy (geothermal)
  - Reduction of fugitive methane emissions through improved wellbore technologies, etc.
- Addresses challenges and opportunities with **water** management
- Drives innovation to improve **safety** associated with subsurface energy operations
- Advances new concepts for safe and responsible disposal of **nuclear waste**
- Increased recovery factors from tight formations can vastly increase the longevity of US **energy security**
- Implementation of a **new collaborative model** to tackle an energy "grand challenge" faced by multiple sectors

Subsurface Control for a Safe and Effective Energy Future

Adaptive Control of Subsurface Fractures and Fluid Flow

Intelligent Wellbore Systems

- Improved well construction materials and techniques
- Autonomous completions for well integrity modeling
- New diagnostics for wellbore integrity
- Remediation tools and technologies
- Fit-for-purpose drilling and completion tools (e.g. anticipative drilling, centralizers, monitoring)
- HT/HP well construction / completion technologies

Subsurface Stress & Induced Seismicity

- Measurement of stress and induced seismicity
- Manipulation of stress and induced seismicity
- Relating stress manipulation and induced seismicity to permeability
- Applied risk analysis of subsurface manipulation

Permeability Manipulation

- Physicochemical fluid-rock interactions
- Manipulating flowpaths
- Characterizing fractures, dynamics, and flows
- Novel stimulation methods

New Subsurface Signals

- New sensing approaches
- Integration of multi-scale, multi-type data
- Adaptive control processes
- Diagnostic signatures and critical thresholds

Energy Field Observatories

Fit For Purpose Simulation Capabilities

FY2014-2015 SubTER Crosscut

What is currently underway?

JASON advisory group report: "State of Stress in Engineered Subsurface Systems," 9/14

Co-funded by 7 DOE offices (FE, EE, NE, EPSA, SC, EM, ARPA-E)

Recommends ***"that DOE take a leadership role in the science and engineering needed for developing engineered subsurface systems, addressing major energy and security challenges of the nation."***

$1.6M FY14 funding towards SubTER lab projects from EERE and FE:

- ***Wellbore*** **–** LANL: 3D acoustic borehole integrity monitoring system
- ***Stress, Permeability*** **–** LBNL: Field Laboratory in a Deep Mine for the Investigation of Induced Seismicity and Fracture Flow
- ***Stress*** **–** LANL: Evaluating the State of Stress Away from the Borehole
- ***Stress*** **–** ORNL: Luminescence spectroscopy stress sensor for in-situ stress measurement
- ***Stress*** **–** NETL: Big Data and Analytics for Induced Seismicity
- ***New Signals*** **–** PNNL: Borehole muon detector for 4D density tomography of subsurface reservoirs

Seed funding to these projects will kick-start efforts in FY15, FY16 and beyond . . .

FY2015 Example Priority Aligned Activities Within Offices

Energy Efficiency and Renewable Energy

- FORGE (Frontier Observatory for Research in Geothermal Energy)

Nuclear Energy, Office of Used Nuclear Fuel Disposition

- Activities related to initiating the Deep Borehole Field Test in FY16, which is a high priority item for the Office of Nuclear Energy

Fossil Energy, Oil & Gas and Carbon Storage

- NRAP
- Unconventional Resources Field Laboratories

Science, Basic Energy Science (BES)

- Foundational Research
- EFRCs: Centers for Geologic Storage of CO2, Frontiers of Subsurface Energy Security, and Nanoscale Controls on Geologic CO2

Environmental Management

- Investigate the use and development of universal canisters for EM waste disposal in borehole

At least $6M could be available for collaboratively funded SubTER projects in FY15. This builds on the kick-off "seed" funding for $1.6M in FY14. Details will be communicated in coming months at energy.gov/subsurface-tech-team

How can the Academic Community be Involved?

- **Your input now can contribute to shaping the scope of SubTER.**
- **Funding opportunities will be announced leading up to and/or after the full launch of this initiative in FY16 (pending appropriations).**
- **Partnerships with National Labs can facilitate involvement in other aspects of the Subsurface Crosscut starting in FY15.**

The Quadrennial Technology Review (QTR)

The 2015 Quadrennial Technology Review (QTR 2015) will examine the most promising research, development, demonstration, and deployment (RDD&D) opportunities across energy technologies to effectively address the nation's energy needs. The insight gained from this analysis will provide essential information for decision-makers as they develop funding decisions, approaches to public-private partnerships, and other strategic actions over the next five years.

Contributions are encouraged for identifying key RDD&D opportunities, approaches to analysis of the RDD&D portfolio, and means for accelerating the RDD&D process. Your comments are welcome and can be sent to: DOE-QTR2015@Hq.Doe.Gov

http://energy.gov/qtr

Please Provide Feedback . . .

- **Do these challenges and related R&D directions, accurately represent the technology landscape related to fracture propagation and fluid flow in the subsurface?**
- **Are there additional areas or themes within this topic, which should be considered?**
- **Is this a high-impact problem or challenge?**
- **Is the topic sufficiently open, i.e., does it address the broad problem, and is it appropriately open to new ideas, approaches, directions?**
- **Does solution of this problem, result in enduring benefit to the United States – economic, environment, etc.? What could be the impact?**
- **What are the gaps between what is being pursued in the private sector, vs. publicly funded R&D?**

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