GSA Town Hall Meeting
Towards a Global Geoscience Initiative

Critical Research Challenges in Natural Resource Geosciences for the Early 21st Century

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Framing the Issue

- What is the overarching challenge facing humanity in the early 21st century?

Sustainable existence on planet Earth

(+ increased living standards for much of the world's population)

The Real Driver for the Challenge — Population Growth (human system)

2005		2030 estimates	
China	1.31	India	1.53
India	1.09	China	1.46
USA	0.29	USA	0.36
Indonesia	0.23	Indonesia	0.28
Brazil	0.22	Pakistan	0.23

Source: U.S. Census Bureau

Some strategic issues:
(intersections between human and earth systems)

- Growth of mega-cities and need for energy
- Restructuring of global capital and debt
- Renewable energy growth and land use
- U.S., China, coal, and carbon
- Coupling of IT and natural resources growth
- Unanticipated discoveries / technologies
- Unanticipated consequences

Framing the Issue — Natural Resources

- How do the natural resources geosciences relate to the global challenge?

Energy

Water

Earth Materials

Through the twin prisms of environmental sustainability and climate change

Natural Resource Issues Involve Complexity:

Science and Technology

+

Economics and Business

+

Society and Environment

+

Policy and Government

Natural Resources - Energy

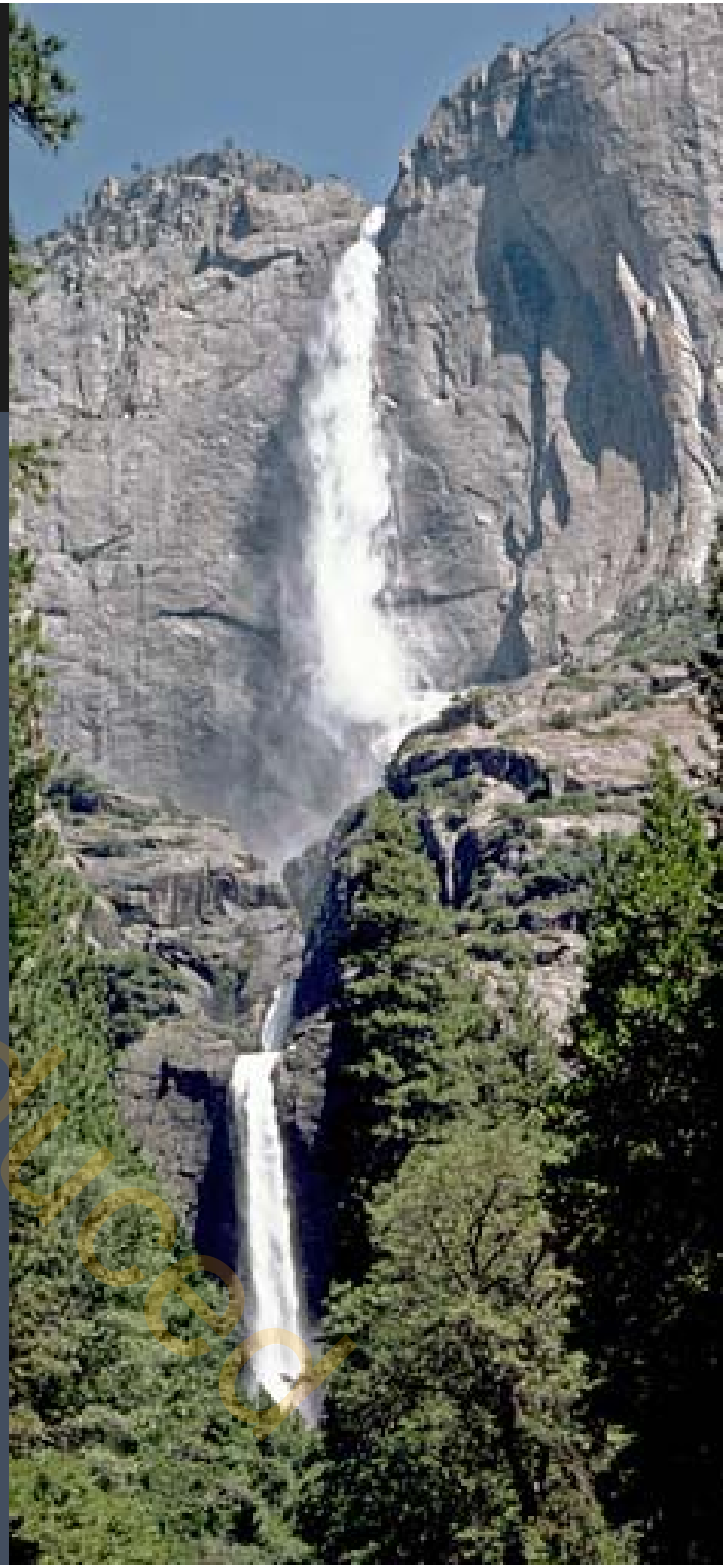
- Fossil fuels (coal, petroleum, natural gas, unconventional fossil)
- Nuclear
- Renewables (hydro, solar, wind)

Natural Resources - Energy

- Production
  - Finding more
  - Producing and using what we have most efficiently
- Environment – wastes
  - Solids
  - Gases
  - Liquids
  - Heat *(lost energy)*

Natural Resources - Water

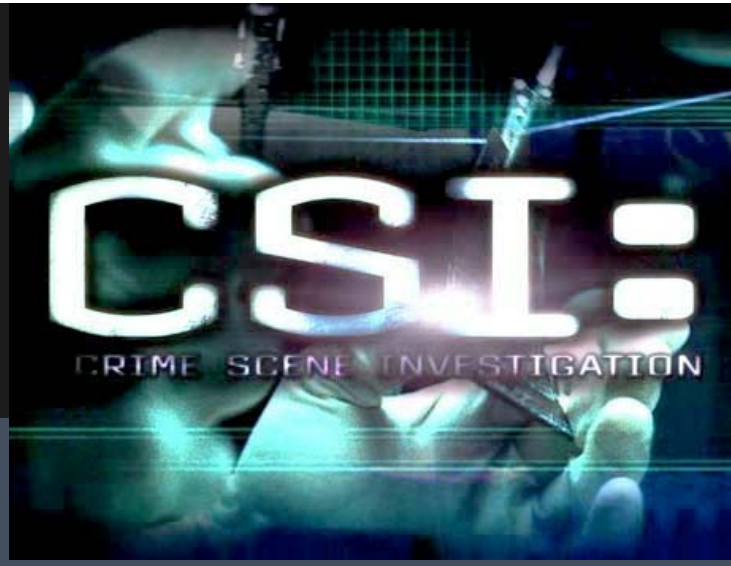
- Quantity and quality
- Reuse



Natural Resources – Earth Materials

- Production
  - Finding more
  - Using what we have most efficiently
- Environmental impacts
  - Wastes
  - Land use
  - Energy

Geosciences (Forensics) [earth system]



- Geoscientists have generally focused on forensic science
  - Examine the scene of the crime
  - Do an autopsy

Like medical practitioners who have traditionally diagnosed problems after they happen.

Predictive Geosciences [earth + human systems]

Like medicine, we must move toward predictive and integrative geology.

But see how challenging it can be – current health care debate!

Framing the Issue — Natural Resources

What unique skills do geoscientists bring to the table?

UNDERSTANDING THE EARTH SYSTEM &

SCALE & TIME

But we have less expertise integrating

earth and human systems

Natural Resource Implications - SCALE
Trillion is the magic number*

- Trillion gallons of fuel consumed per year
- Half a trillion gallons of water withdrawn per day in US
- Trillion watts of U.S. power generation capacity
- Trillion barrels of oil consumed in the last 125 years
- Two trillion pounds of sand & gravel consumed in US / year
- Three trillion pounds of copper consumed in the last decade
- Trillion tons of coal reserves
- More than $20 trillion in capital needed in 25 years for energy

Even for geoscientists, the scale of earth-human system issues is enormous!

*** Modified from Donald Paul, William Keck Chair of Energy, USC**

Natural Resource Implications - SCALE "1% matters" — examples in energy

- Adding 1% to global oil reserves requires about $200 billion in exploration and production investment.
- U.S. ethanol production is about 1% of total global liquids production.
- Installing 10 GW of solar PV in the US would add 1% to total electric capacity.
- 2.5 million electric vehicles would displace 1% of US fuel demand (100,000 bbl/day).

Natural Resource Implications - SCALE

- Enhanced Geothermal (EGS)
  - How to manipulate and control both subsurface heat and seismicity *(crustal scale)*
- Fluid / gas movement
  - How to understand and manipulate materials at the *nano-scale* in geological environments.

Natural Resource Implications – TIME hundreds to millions of years

- Most individuals think seriously in terms of one to three generations (~150 years).
- Natural resource issues (earth + human systems) must be considered in 100's to 1000's of years.
  - Peak oil
  - Peak coal
  - Nuclear waste disposal
  - Aquifer recharge
- Geoscientists must routinely think in millions of years.

Natural Resource Implications – TIME

- Energy — natural gas, coal to liquids, oil shale, algal biofuels
  - Fracturing — pump from the source rock
  - In-situ creation of new liquids and gases
  - Genetic modification of algal materials and processes

Speed up geologic time!

Natural Resource Implications - TIME

- Earth materials
  - In-situ leaching (chemical, biological)
  - Co-produce metals from geothermal
  - Tap active sea-floor hydrothermal vents

Hasten geochemical processes

Natural Resource Implications - TIME

- Environment — carbon capture and sequestration (CCS)
  - Utilize and create subsurface reservoirs
  - Innovative ways to tie up CO_2

Create or manipulate subsurface permeability and reaction processes at geologically meaningful scales

Complexity, scale, and time: Natural Resources

Past,
present,
and future
always co-exist.

Energy
Water
Environment

Earth System
Resources
Knowledge

+

Human System
Technology
Values

=

Sustainable Existence

Natural Resources:
Research Challenges — Overarching Themes

- How to better understand and engineer fluids (of all types) in the subsurface
  - *Energy (oil and gas; hydrothermal fluids)*
  - *Water*
  - *Environmental (CO_2)*

Predictive Geo-engineering

Natural Resources:
Research Challenges — Predictive Geoengineering

- At all scales and through time.
- Utilize natural test sites (e.g. Earthscope) and human manipulated test sites (oil fields, major aquifers – Ogallala, etc.)
  - Field geology (traditional mapping)
  - Laboratory (empirical analysis)
  - Remote sensing (geophysics)
- Synthesis and predictive studies and tests

Global Geoscience Initiative - Natural Resources: *Integrating the Earth and Human Systems*

- Undertake the necessary *predictive* geoscience research – e.g. subsurface engineering
- Understand the societal context of this science
- Science + Social Sciences + Humanities
- Genuine dialog with those outside our discipline
- Engage with the public and public policy making

New Global Initiative:

Undertake required science

Communicate findings (scale, time, complexity)

Understand other perspectives