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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20 October 2009
Acknowledgements

- A number of individuals were contacted concerning the issue of grand challenges in natural resources geosciences – thanks to all! But especially —

- Mark Barton
- Maeve Boland
- Larry Cathles
- Stephen Kesler
- Donald Paul
- Jeremy Richards
- Steve Sonnenberg
- Scott Tinker
- Neil Williams
Framing the Issue

- What is the overarching challenge facing humanity in the early 21\textsuperscript{st} century?

\textit{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)

<table>
<thead>
<tr>
<th>Country</th>
<th>2005</th>
<th>2030 estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>1.31</td>
<td>1.46</td>
</tr>
<tr>
<td>India</td>
<td>1.09</td>
<td>1.53</td>
</tr>
<tr>
<td>USA</td>
<td>0.29</td>
<td>0.36</td>
</tr>
<tr>
<td>Indonesia</td>
<td>0.23</td>
<td>0.28</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.22</td>
<td>0.23</td>
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</tbody>
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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.*
Like medicine, we must move toward predictive and integrative geology.

But see how challenging it can be – current health care debate!
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 $\text{CO}_2$

*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.

Earth System
Resources
Knowledge

+ Human System
Technology
Values

Energy
Water
Environment

= 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 (CO₂)*

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*