
Geological,
Environmental &
Planetary Sciences

GEP Team

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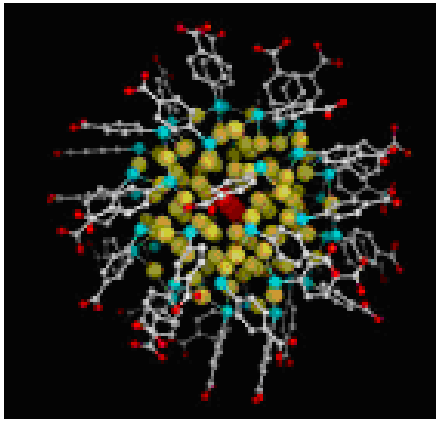
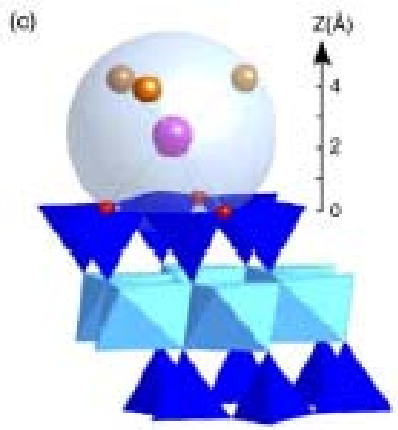
(Those here at workshop in bold)

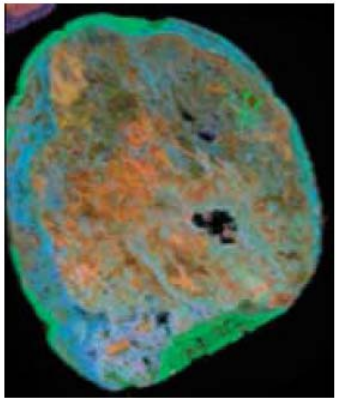
Science Priorities



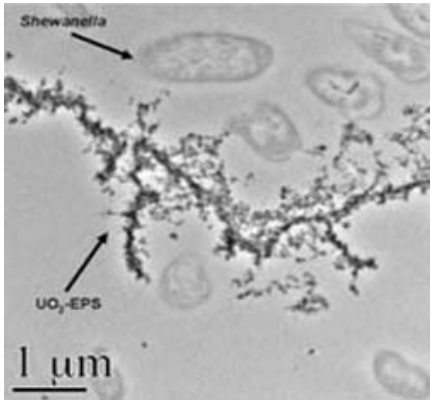
Nanoparticles



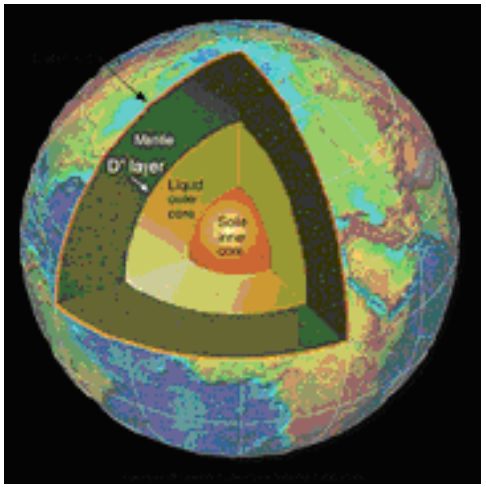
Mineral-Fluid Interface



Trace Elements:
Speciation and Transport

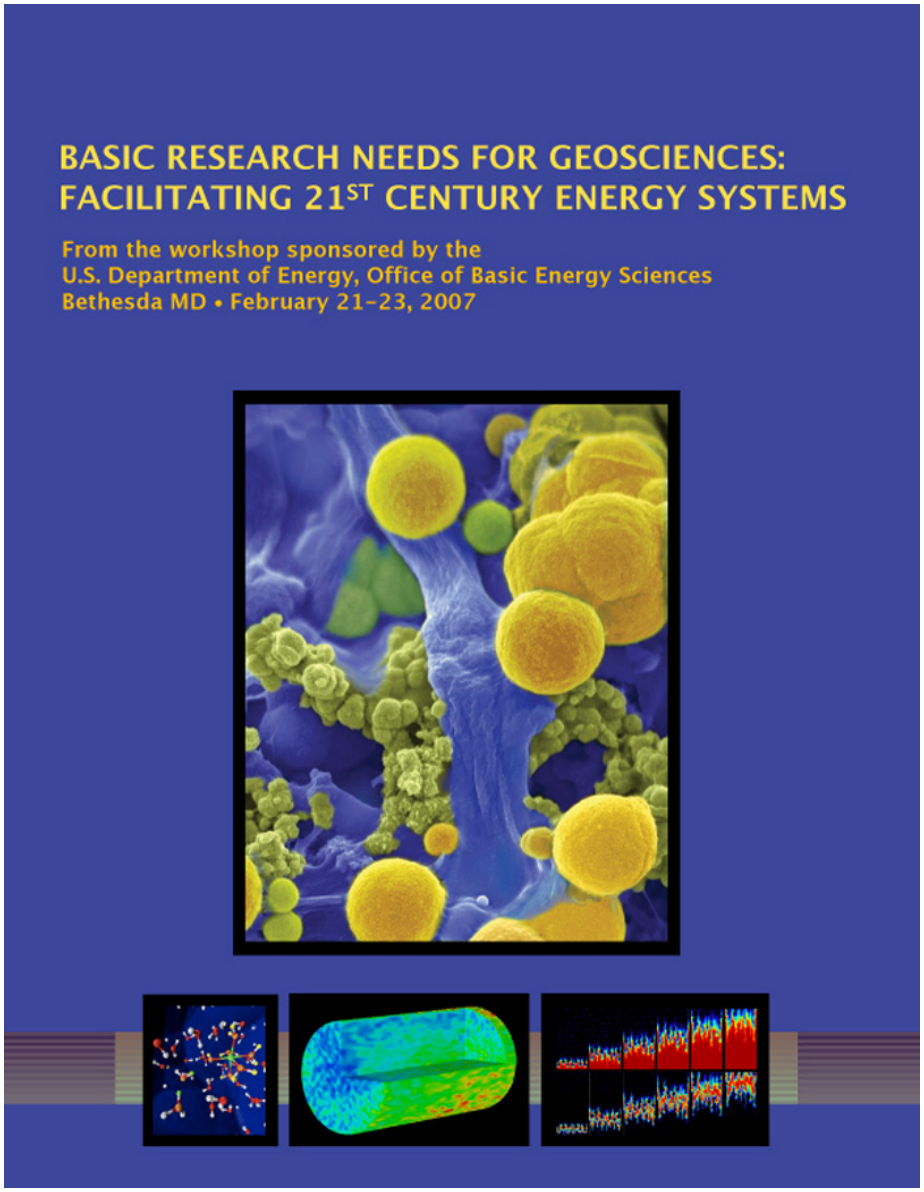


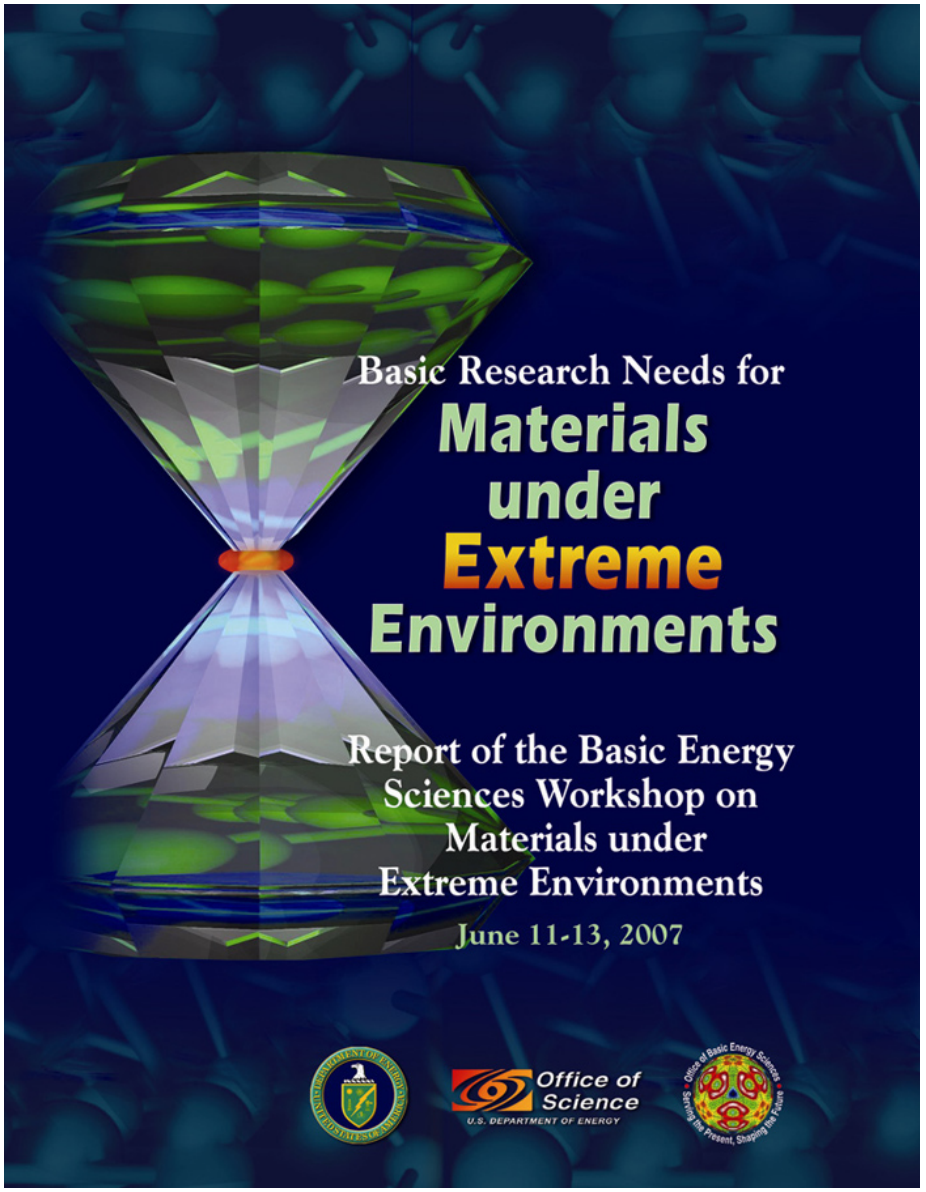
Geobiology



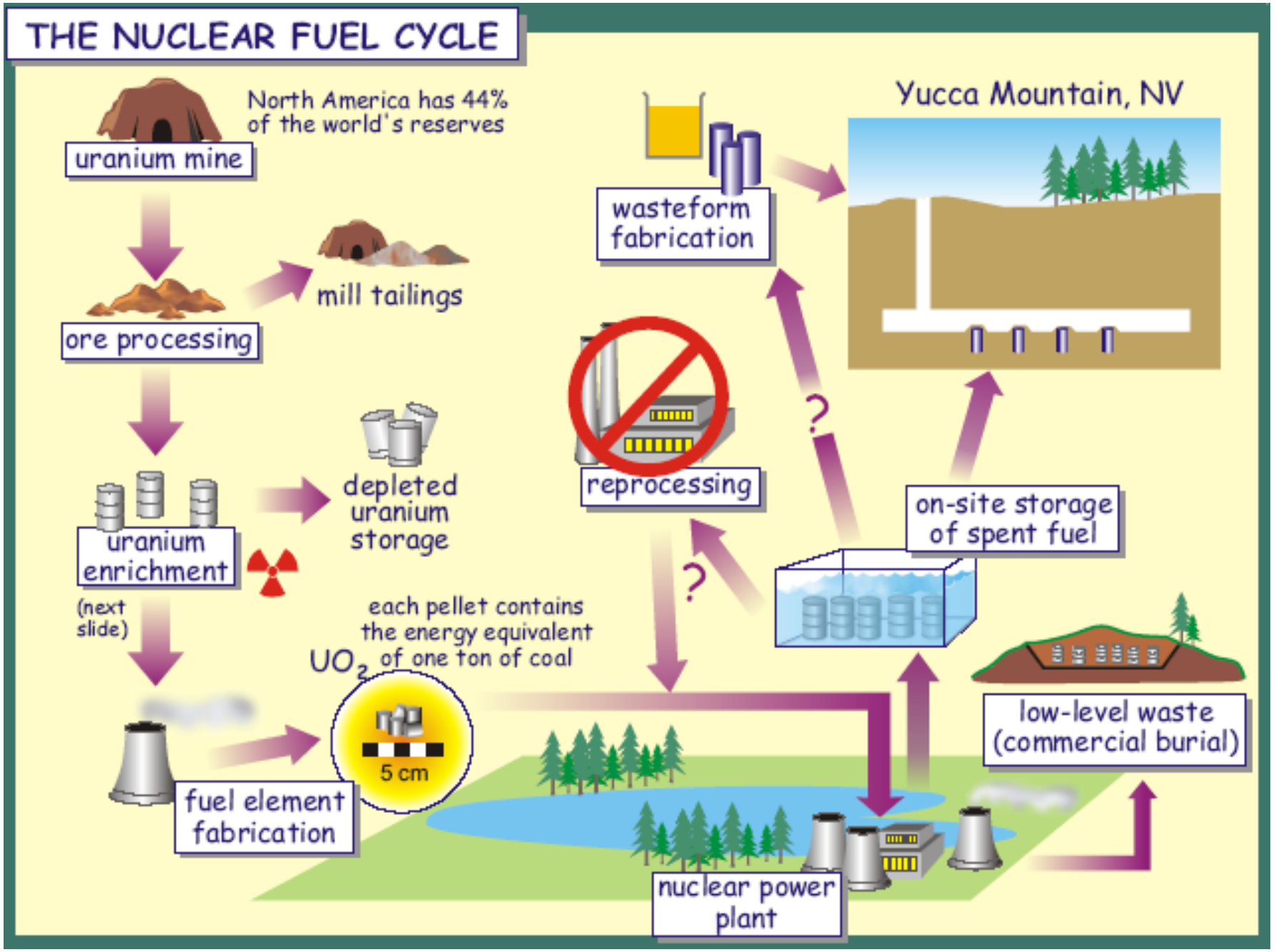
Mineral Physics (hi-P)

Cosmochemistry &
Planetary Science

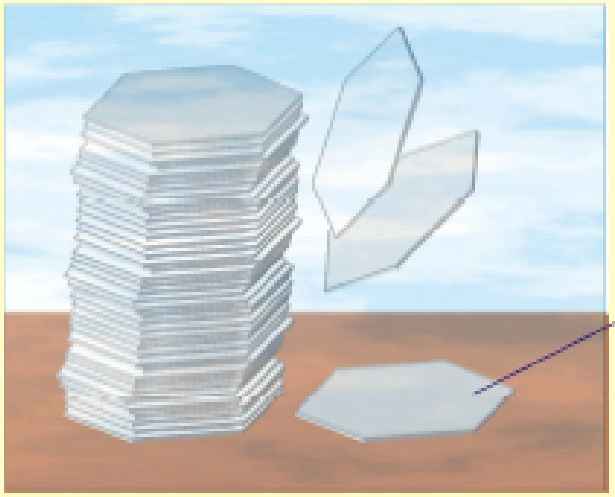


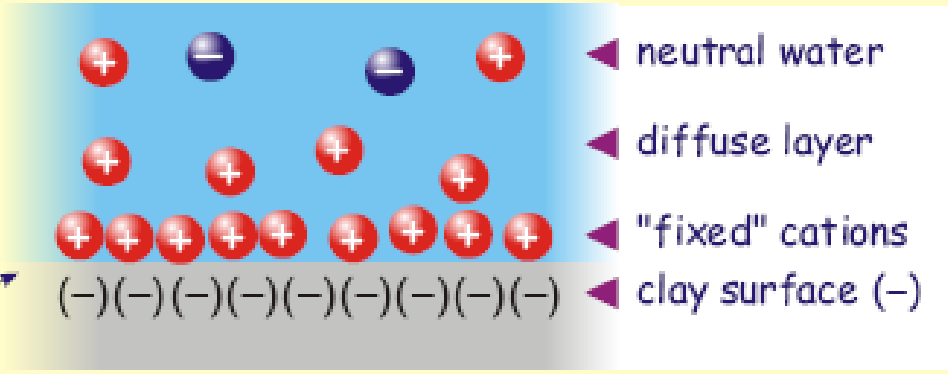


Relevant Basic Research Needs Workshop Reports

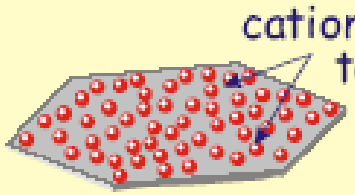

THE NUCLEAR FUEL CYCLE
North America has 44% of the world's reserves
uranium mine
ore processing
mill tailings
uranium enrichment
depleted uranium storage
(next slide)
each pellet contains the energy equivalent of one ton of coal
UO_2
5 cm
fuel element fabrication
wasteform fabrication
Yucca Mountain, NV
reprocessing
?
?
on-site storage of spent fuel
low-level waste (commercial burial)
nuclear power plant

CLAY PARTICLES (in water) as ion adsorbers

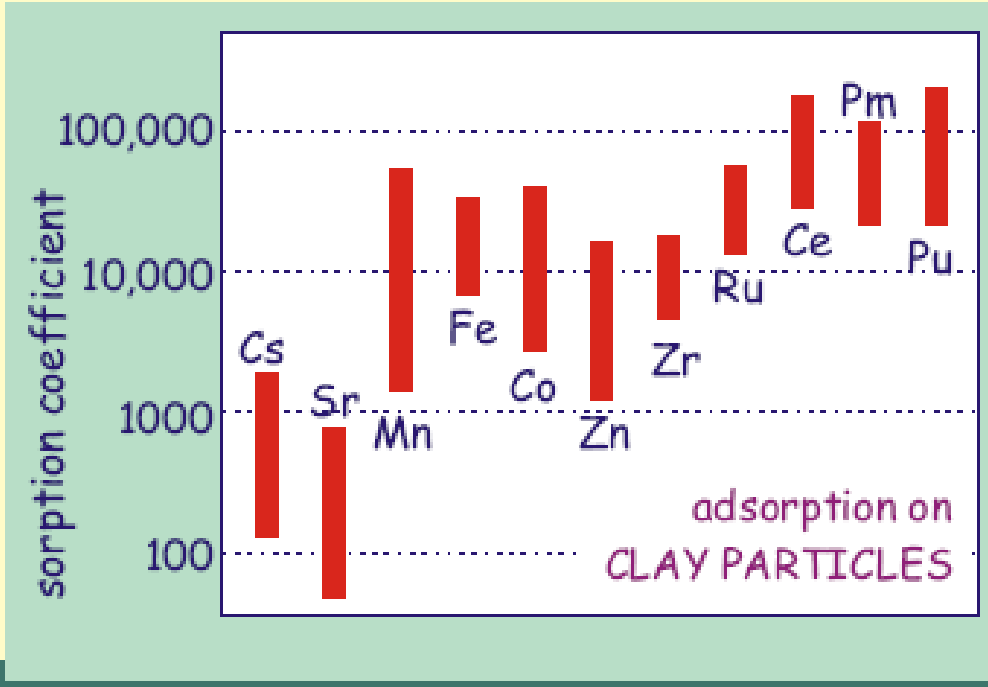




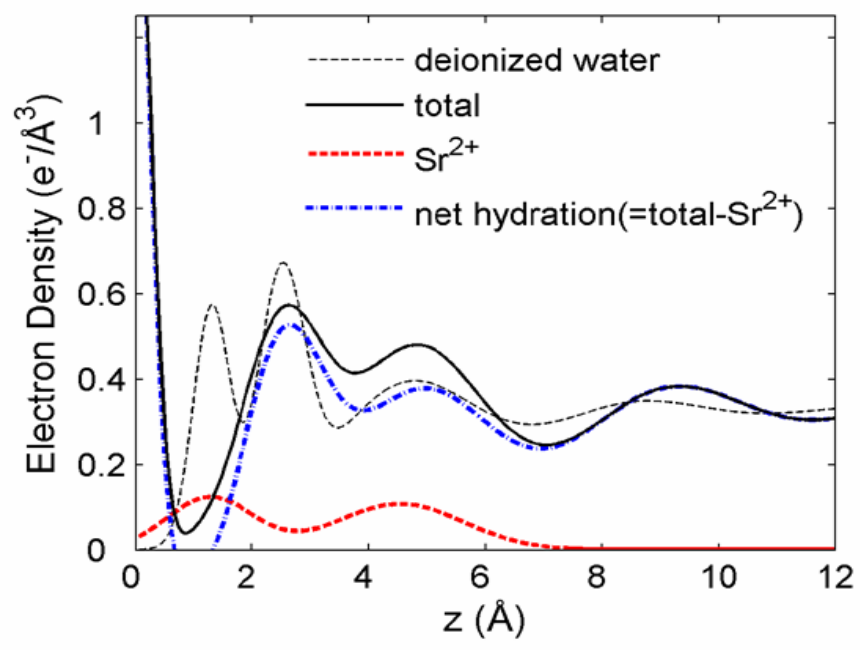
clay particle

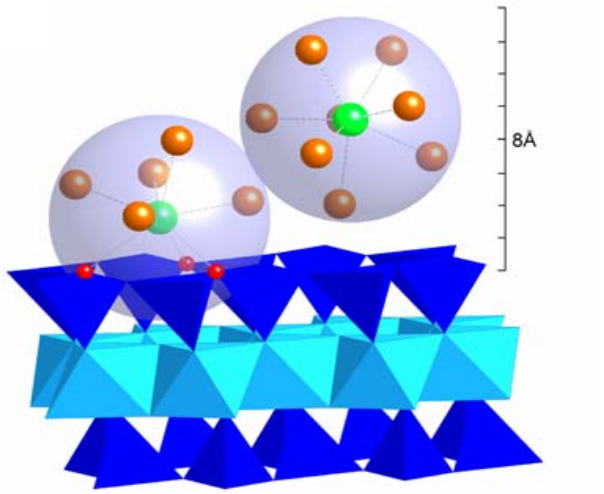


(~10,000 times the diameter of an atom)



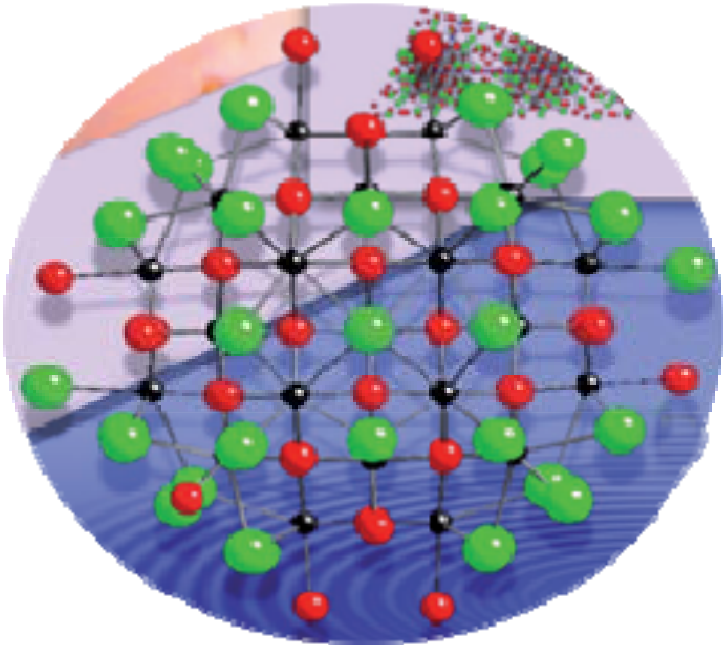
Progress in understanding interfacial geochemistry of solute ions



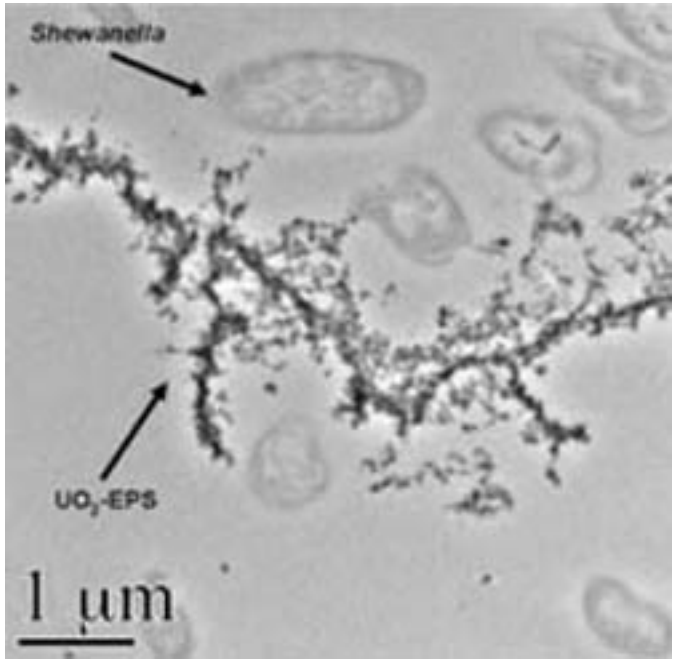


Using RAXR to characterize distribution of adsorbed ions at mica-water interface – finding roughly equal amounts of both inner-sphere and outer-sphere Sr (Park et al., *Phys. Rev. Letters*, 2006)

Progress in understanding environmental behavior of actinides

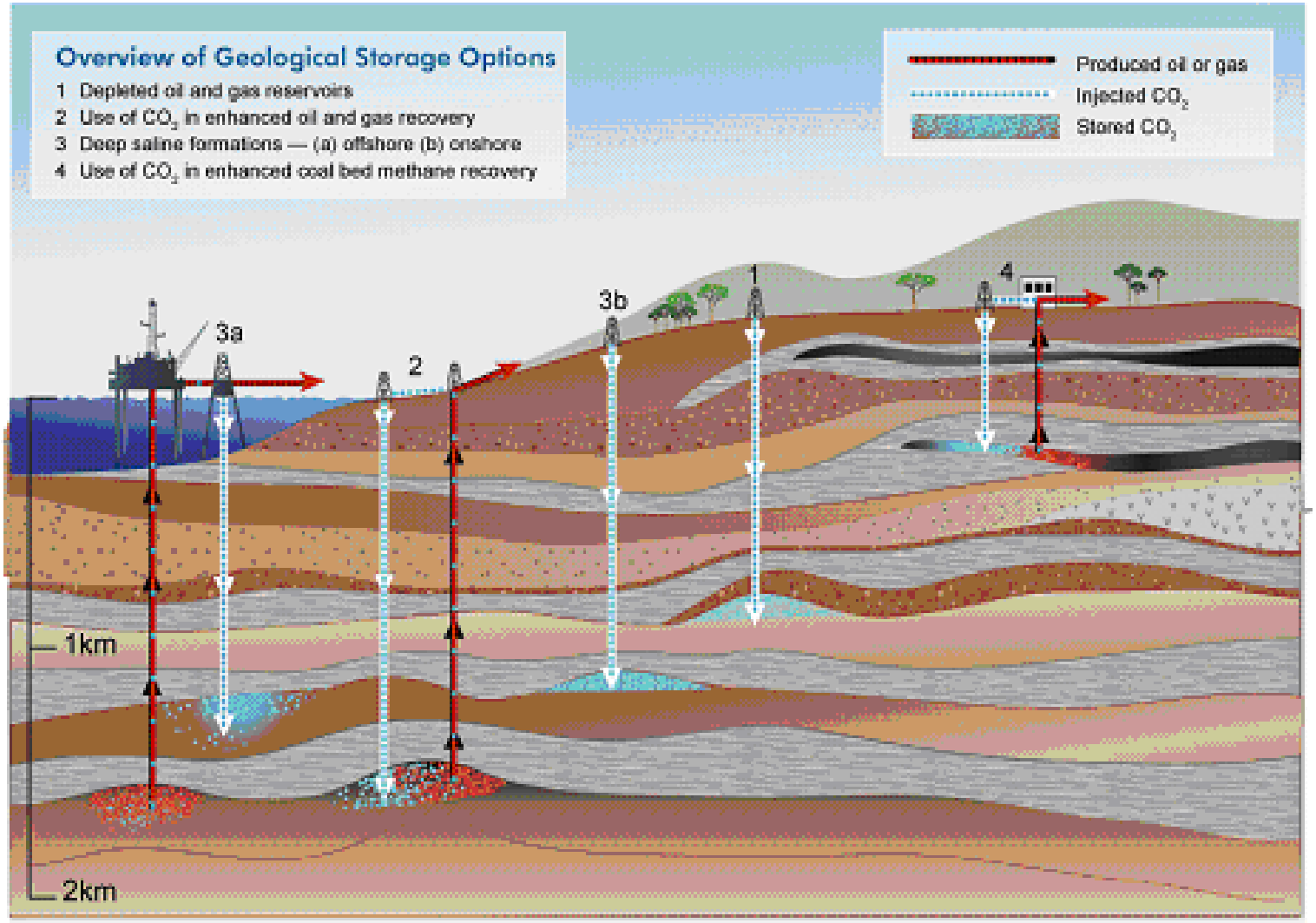


Structure of Pu-oxide nanoclusters discovered using HEXS (Soderholm et al., *Angew. Chem. Int. Ed.,* 2008)



Bacterial reduction of U by c-type cytochromes associated with extracellular polymeric substances around *Shewanella* (Marshall et al., *PLoS Biology*, 2006)

Geological CO_2 sequestration: Will it work?

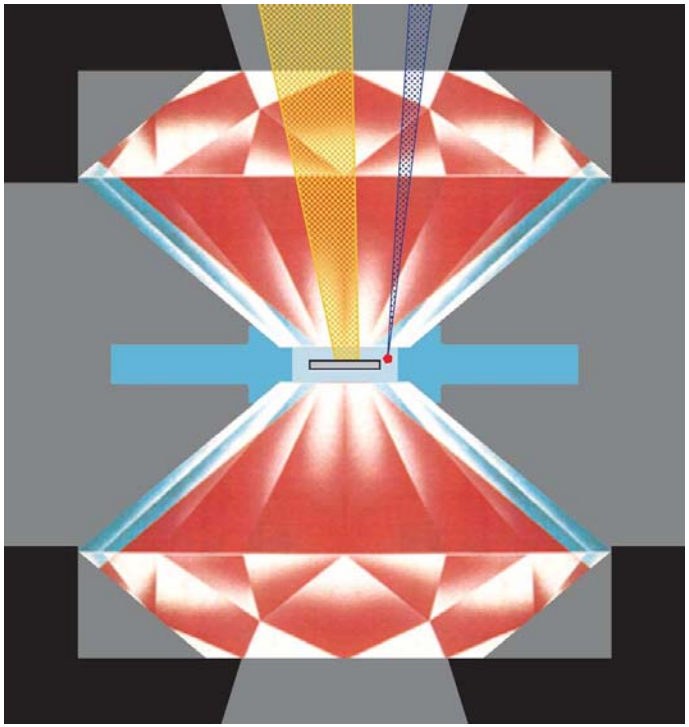


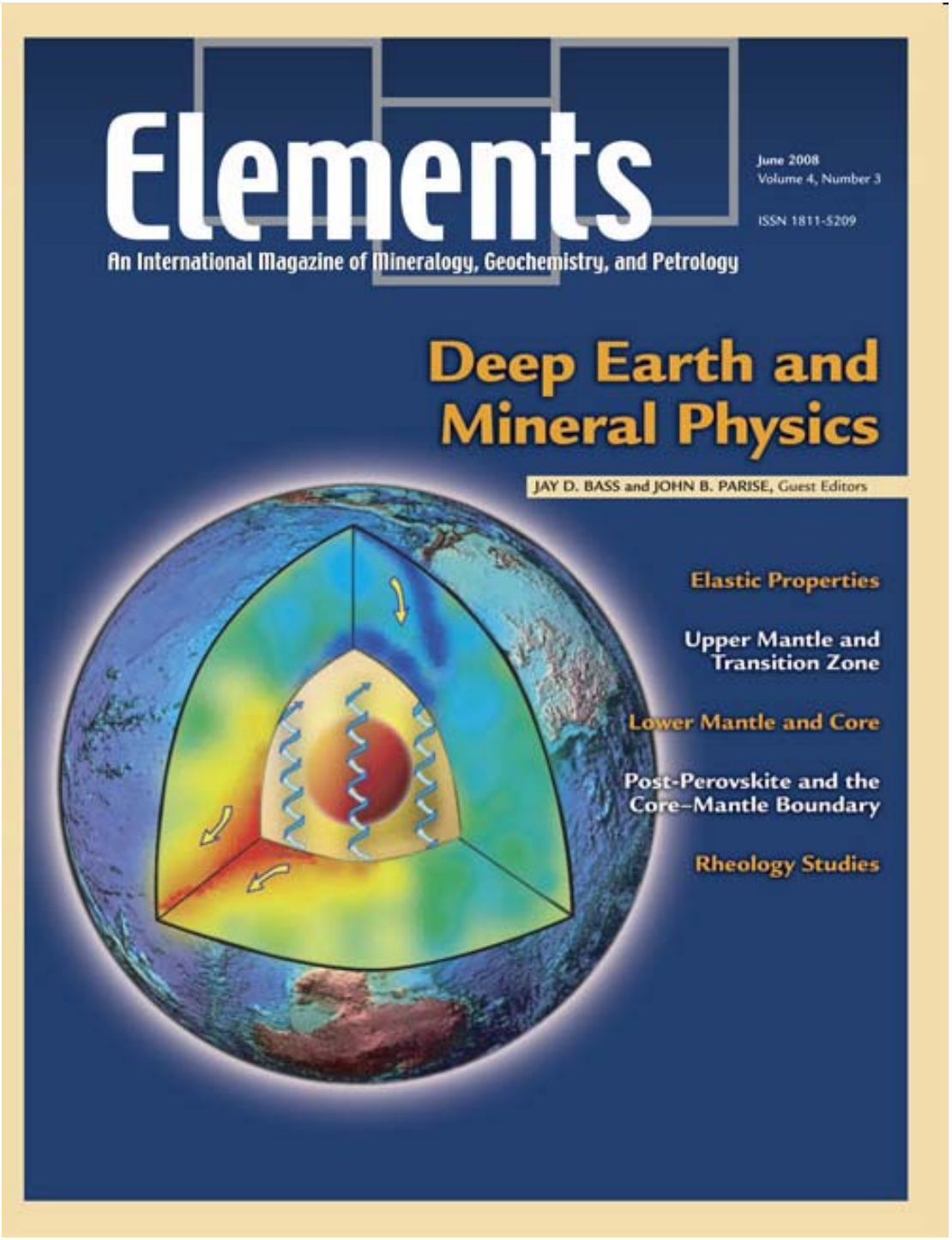
Geobiology

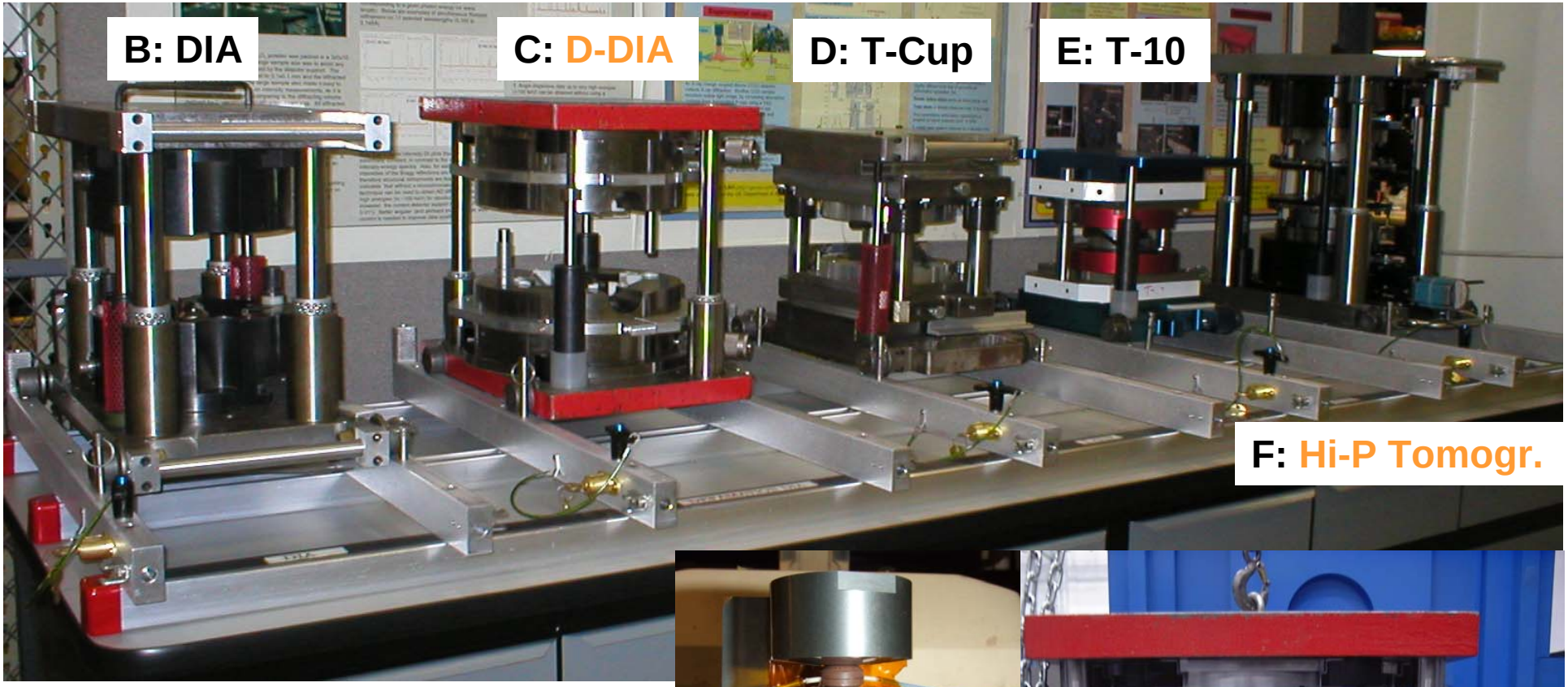
Aerosol generation and transport

Wetland ecology and nutrient cycles

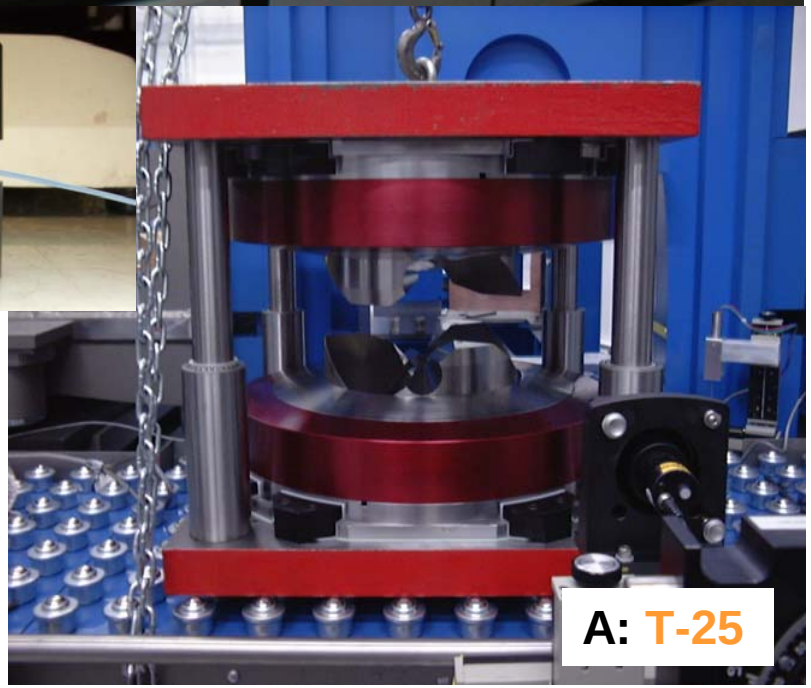
Unlocking Earth's deepest secrets using the diamond-anvil cell!







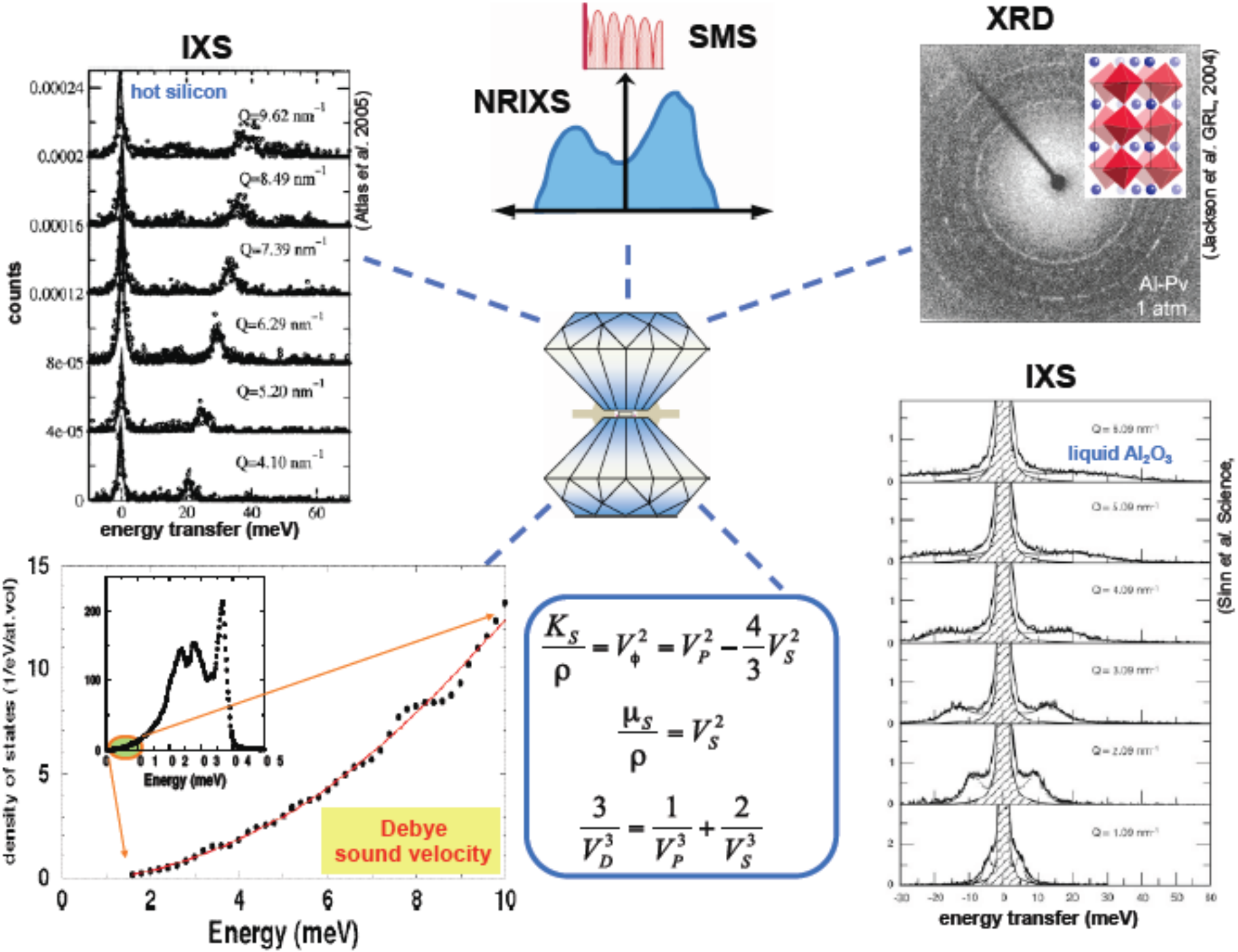
G: Toroidal cell



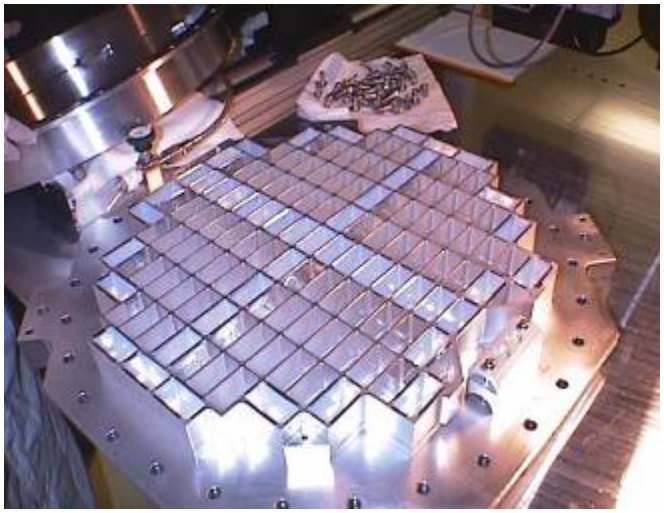
Large Volume Presses

13-IDD (1000 ton), 13-BMD (250 ton)

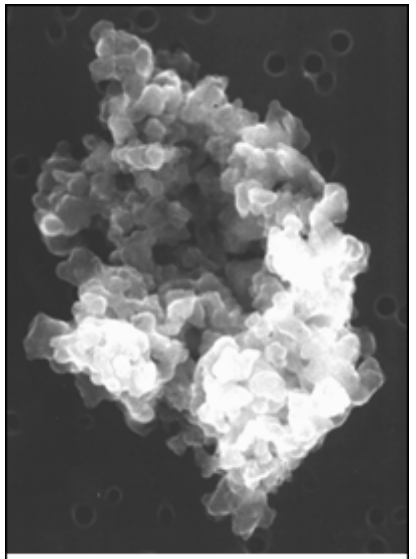
- **Less common than diamond anvil cell**
  - **Only 2 in US, other is at X-17 at NSLS**
- **More complex and precise experiments possible, to lower pressures (30 GPa)**


IXS
hot silicon
Q=9.62 nm⁻¹
Q=8.49 nm⁻¹
Q=7.39 nm⁻¹
Q=6.29 nm⁻¹
Q=5.20 nm⁻¹
Q=4.10 nm⁻¹
counts
energy transfer (meV)
(Atlas et al. 2005)
SMS
NRIXS
XRD
Al-Pv
1 atm
(Jackson et al. GRL, 2004)
IXS
liquid Al2O3
energy transfer (meV)
(Sinn et al. Science,
density of states (1/eV/at.vol)
Energy (meV)
Debye
sound velocity
$\frac{K_S}{\rho} = V_\phi^2 = V_P^2 - \frac{4}{3}V_S^2$
$\frac{\mu_S}{\rho} = V_S^2$
$\frac{3}{V_D^3} = \frac{1}{V_P^3} + \frac{2}{V_S^3}$

Cosmochemistry

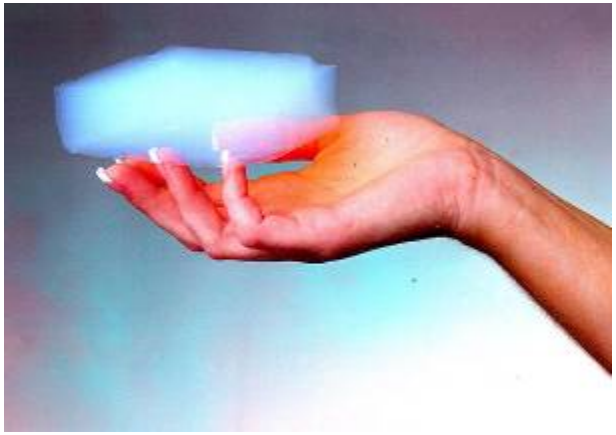


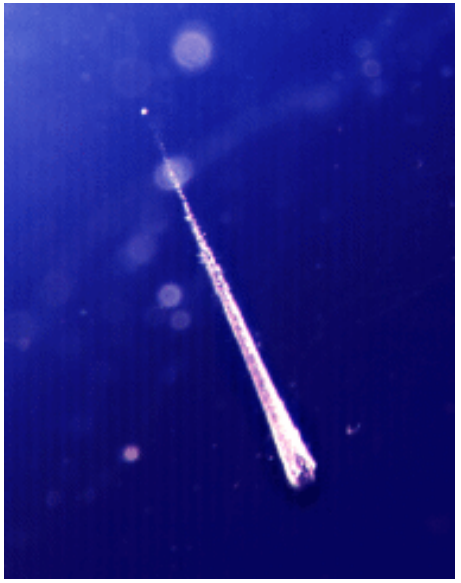
Synchrotron Radiation Studies of Comet Particles Embedded in Aerogel



Cosmic dust grain 11 micrometers in diameter.

- Particle locations using tomography
- Compositions using XRF
- Oxidation states using XAFS
- Mineral identification using XRD





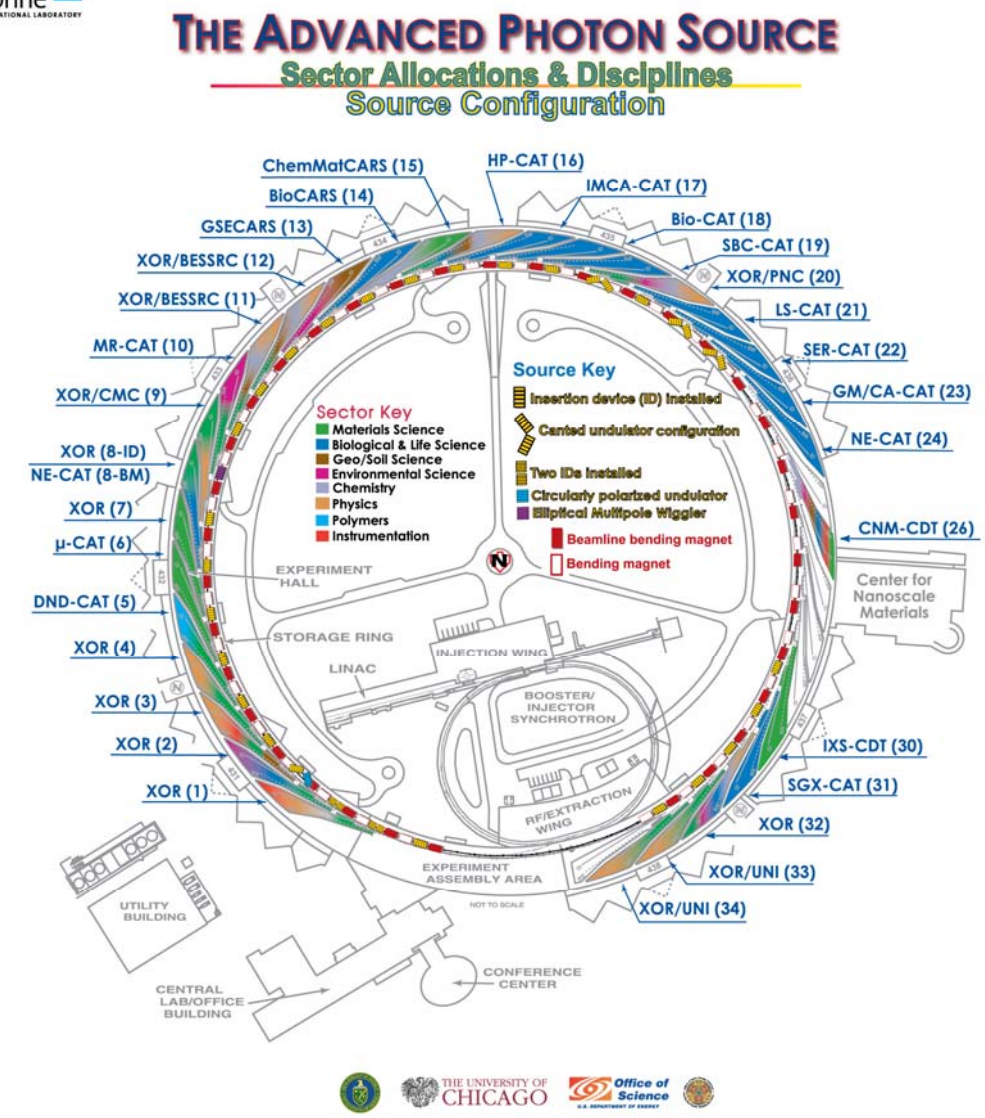
Planetary Science

How well can we predict the composition and behavior of other planets?

Cryovolcanism on Titan

APS Beamlines for GEP Research

(~15% of APS beamtime)



- 1-ID (XOR)
  - High-energy scattering
- 2-ID (XOR)
  - Sub-micron microprobe, 6-15 keV (2-ID-D, 2-ID-E), 1-4 keV (2-ID-B)
- 3-ID (XOR)
  - High-resolution IXS, NRS
- 5-ID, 5-BM (DND-CAT)
  - Tomography, XAS
- 9-BM (XOR/CMC-CAT)
  - XAS, low-energy (S)
- 10-ID, 10-BM (future) (MR-CAT)
  - Microprobe, XAS, diffraction
- 11-BM (XOR)
  - High-resolution powder diffraction
- 11-ID (XOR)
  - High-energy scattering, high-pressure, high-temperature
- 13-ID, 13-BM (GSECARS)
  - High-pressure, microprobe, XAS (micro and bulk), surfaces, microtomography
- 16-ID, 16-BM (HP-CAT)
  - High-pressure, High-resolution IXS, NRS
- 20-ID, 20-BM (XOR)
  - Microprobe, XAS (micro and bulk)
- 26-ID (CNM/XOR)
  - Nanoprobe
- 33-ID (XOR)
  - Surface scattering

A Commonality of APS Science Teams: Studies of Complex Heterogeneous Materials

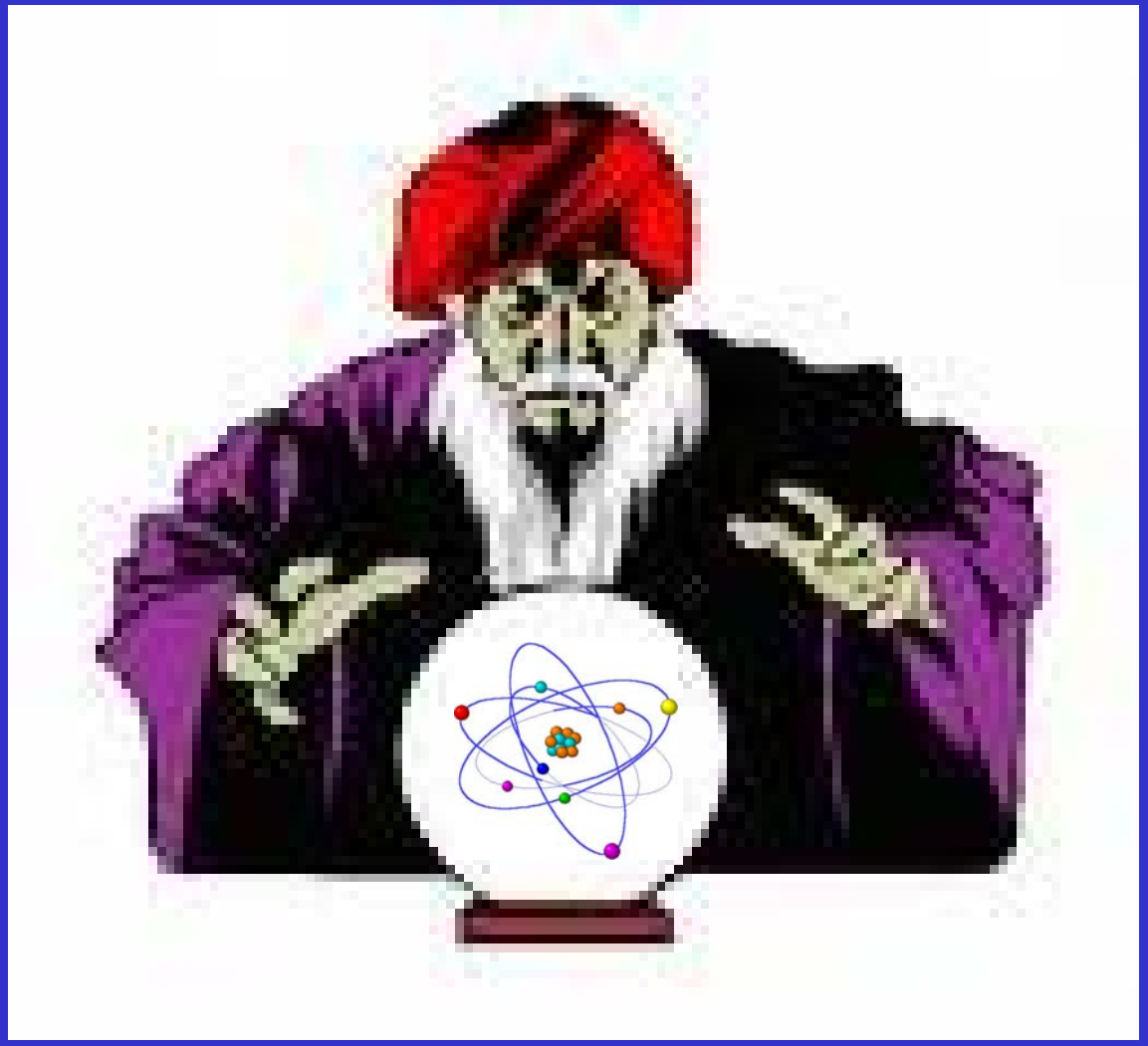
Techniques of GEP Science

- Bulk XRF, XAS, XRD
- Imaging
  - Scanning XRF, XAS, XRD in 2D
  - Tomography – absorption, differential absorption, or fluorescence in 3D
  - X-ray reflection interface microscope (Fenter et al., *Nature Physics*, 2006)
- Diffraction and scattering
  - High-resolution powder diffraction
  - Surface & interface studies – X-ray reflectivity (XR), resonant anomalous XR, X-ray standing waves
  - High-energy X-ray scattering (PDF methods)
  - Inelastic scattering; nuclear resonant scattering; X-ray Raman

Needs

- Higher flux & brilliance, smaller spots, better time resolution

  (any of this sound familiar?)



What will the future bring to APS?

APS Renewal Proposal
Geological, Environmental, and Planetary Sciences (GEP)
Breakout Meeting, 1-4 p.m.
Tuesday, October 21, 2008, Hickory Ridge Marriott

Agenda

- 1:00 – Introduction and Charge
- 1:15 – Status of ESRF Update (Carsten Detlefs, ESRF)
- 1:45 – Brief overview of draft GEP science report (Neil Sturchio, UIC)
- 2:00 - Roundtable discussion aimed toward achieving a consensus on GEP science priorities to be addressed by the APS renewal
- 3:55 – Adjourn to Summaries and Discussion