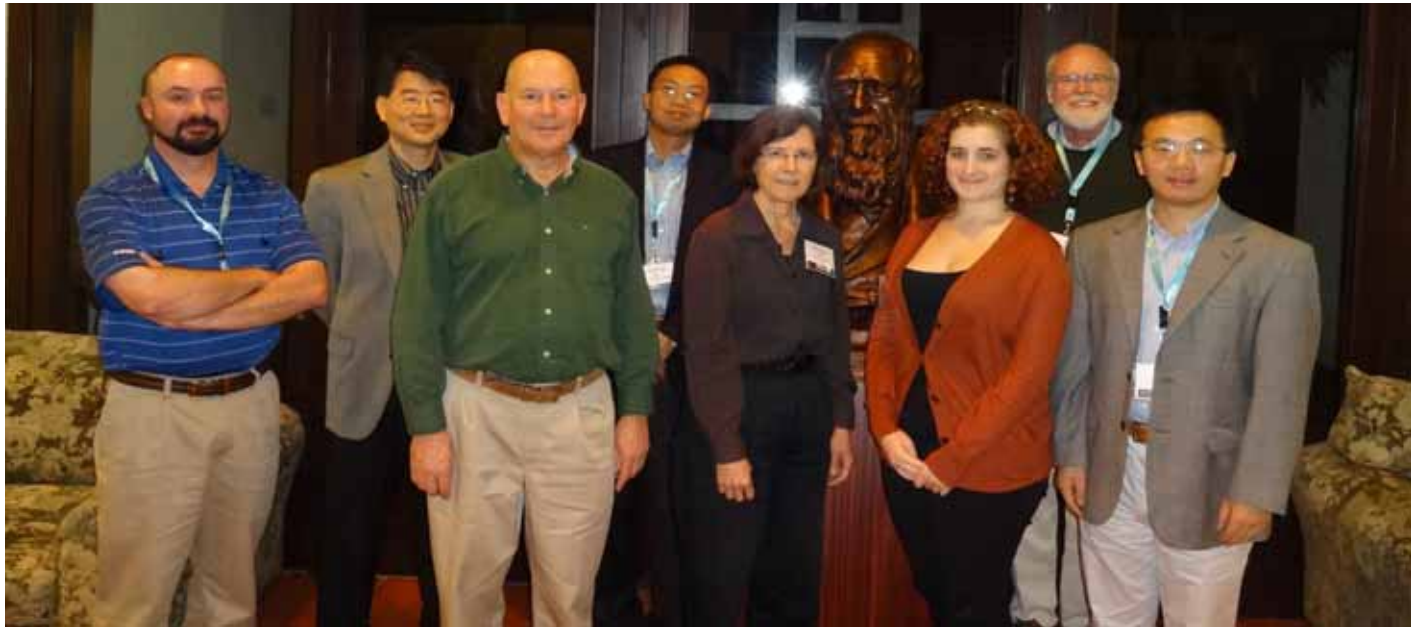
# Team 7A: New & Practical Applications of Nuclear Technologies

**Everything old is new again**

--What's new are enabling technologies (advanced materials & mfrg, computation, nanotech…)

--Many ideas envisioned for a long time but now ripe for investment

Members, left to right: J. Daw, J. Kwon, J. Ausubel (rapporteur), J. Wu, M. Talley, C. Darwin, R. Feltman, J. Holzrichter, S. Mao
Absent: B-A. Schuelke-Leech



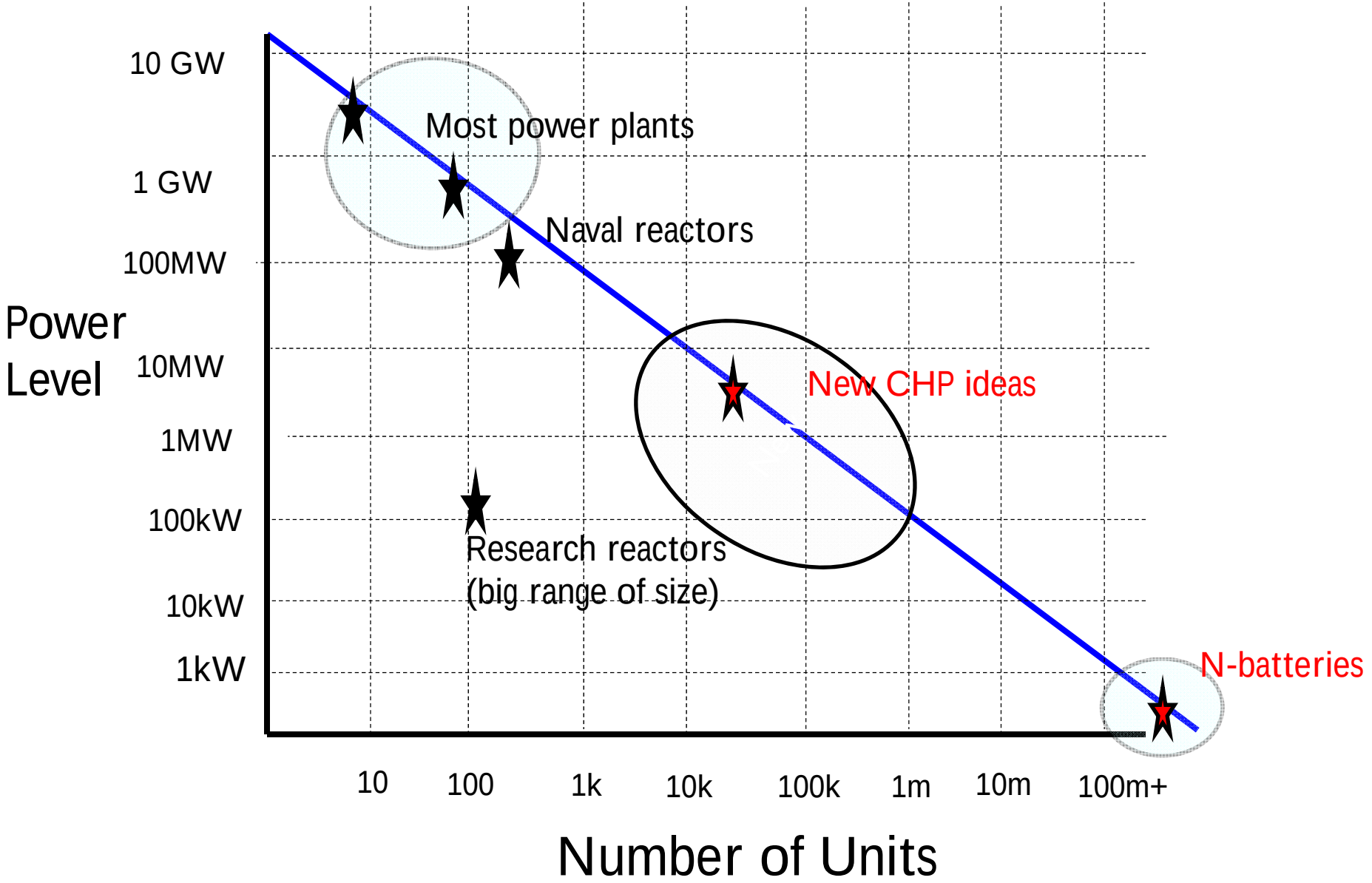
# Current and Prospective Applications Considered

- Heat generation for electricity
- Explosions (military, mining, construction)
- Propulsion (especially space)
- Tracing, imaging, and signaling
- Measuring structures, material characterization
- Medical treatments, mutagenesis of living matter
- Transmutation of elements
- Doping of materials
- Thermochemical cycles via new catalysts
- Food irradiation

# Properties of Nuclear Matter

- Abundant energy, both slow & fast
- Range of kinds of radiation, wavelengths, particles
- Achievement of extreme conditions (high temperature, pressure)
- Control through selection of materials, moderation of processes
- Compact (plants, devices, waste)
- Range of interactions with environment, fallout

# Consider full spectrum of sizes & markets



# Some new applications

- Profitable production of hydrogen via new catalysts
- Combined heat & power (CHP) plants with no moving parts (1KW -10 MW)
- Very long-lived batteries (1-100 mW near future)
- Self-sinking capsules to dispose waste and explore deep in Earth

# Apply "Big Data" approaches to find better catalysts for thermochemical production of $H_2$

>20,000 cycles may merit exploration

Most work so far on sulfur-iodine & bromine, processes at 850$^{o}$C

E.g. , consider alumina

*American Mineralogist, Volume 98, pages 1738–1744, 2013*

**Aluminum speeds up the hydrothermal alteration of olivine**

Muriel Andreani*, Isabelle Daniel and Marion Pollet-Villard

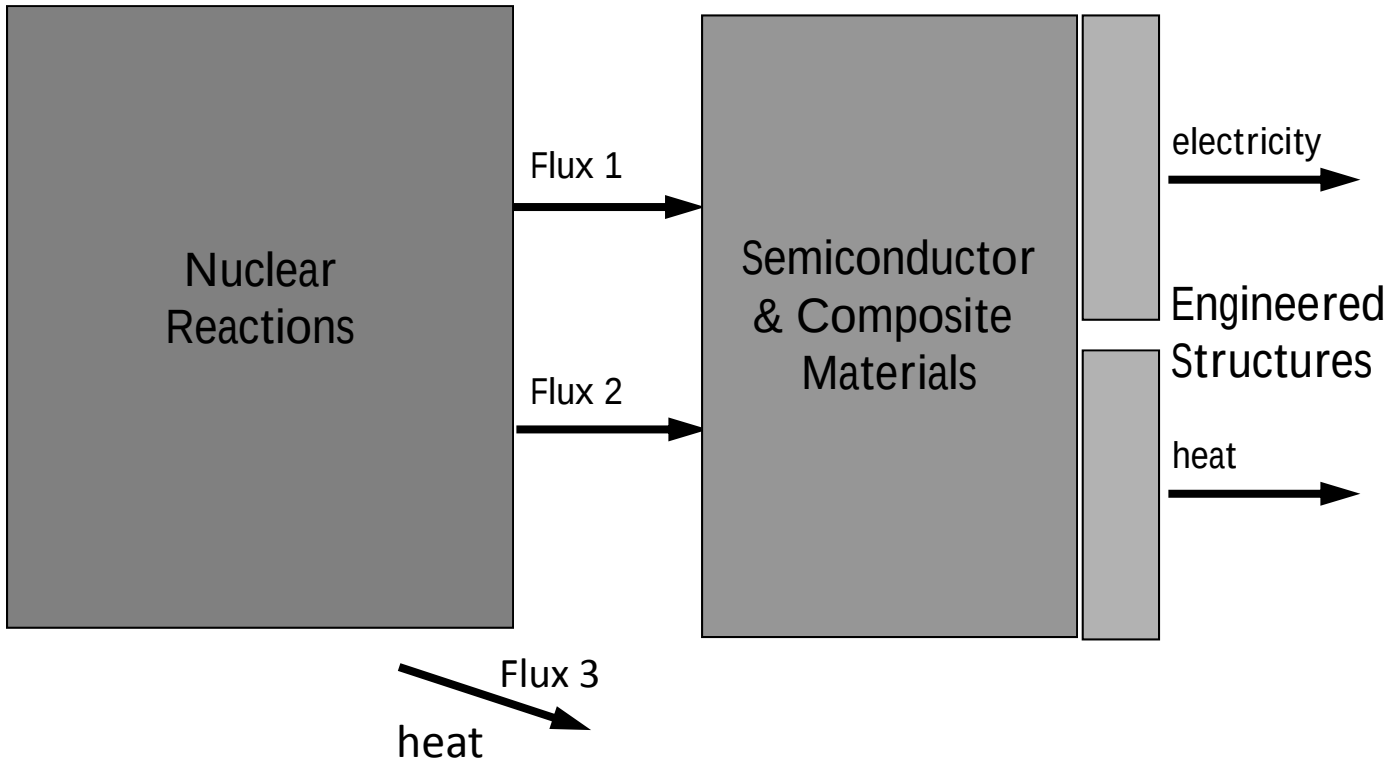
Laboratoire de Géologie de Lyon, France

*Presence of aluminum in hydrothermal fluids increases rate of hydrogen production by one to two orders of magnitude at 200 and 300 °C, 200 MPa.*

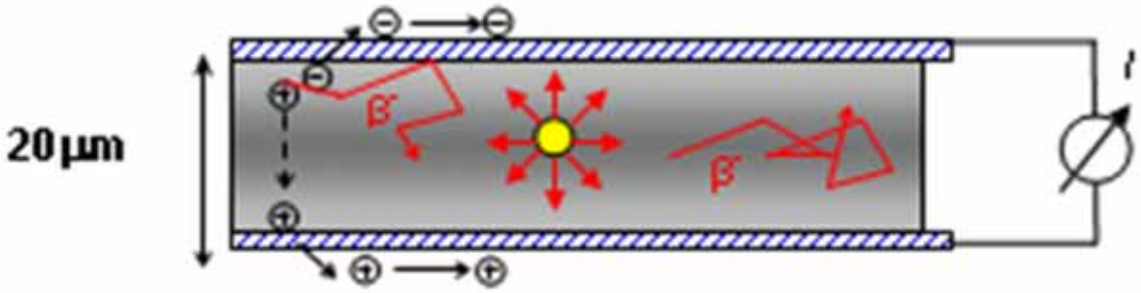
*… "This discovery also opens the potential of the serpentinization* reaction for industrial scale production of hydrogen at economically feasible timescales and temperature."*

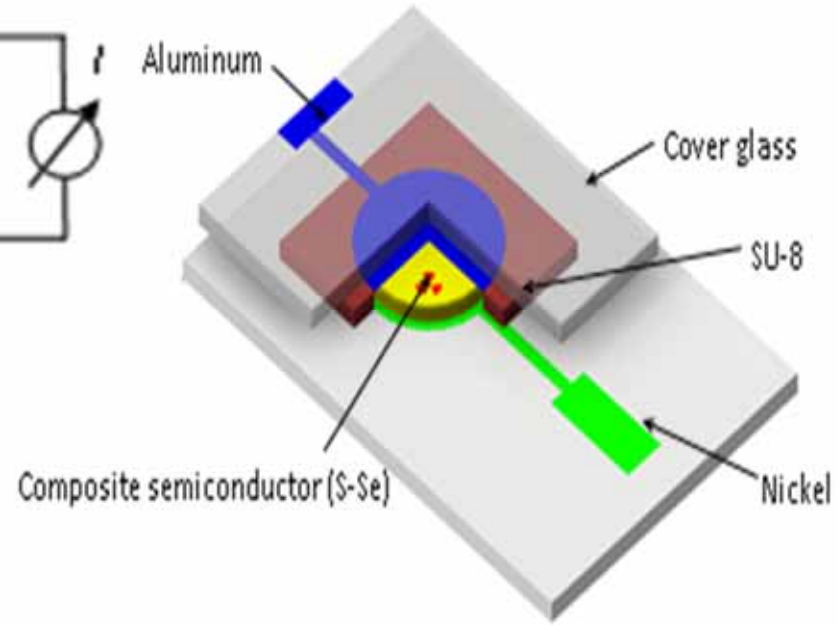
*olivine rock + water = serpentine rock + brucite + magnetite + hydrogen

# Combined Heat and Power (CHP)
# -- all solid-state, no moving parts or working fluid




**Flux may equal heat, light, charged & uncharged particles**




# N-batteries

-To form radioisotope/semiconductor battery, utilized $^{35}S$ and Se

-Radioisotope materials fused inside semiconductor materials to maximally use energy from the sources

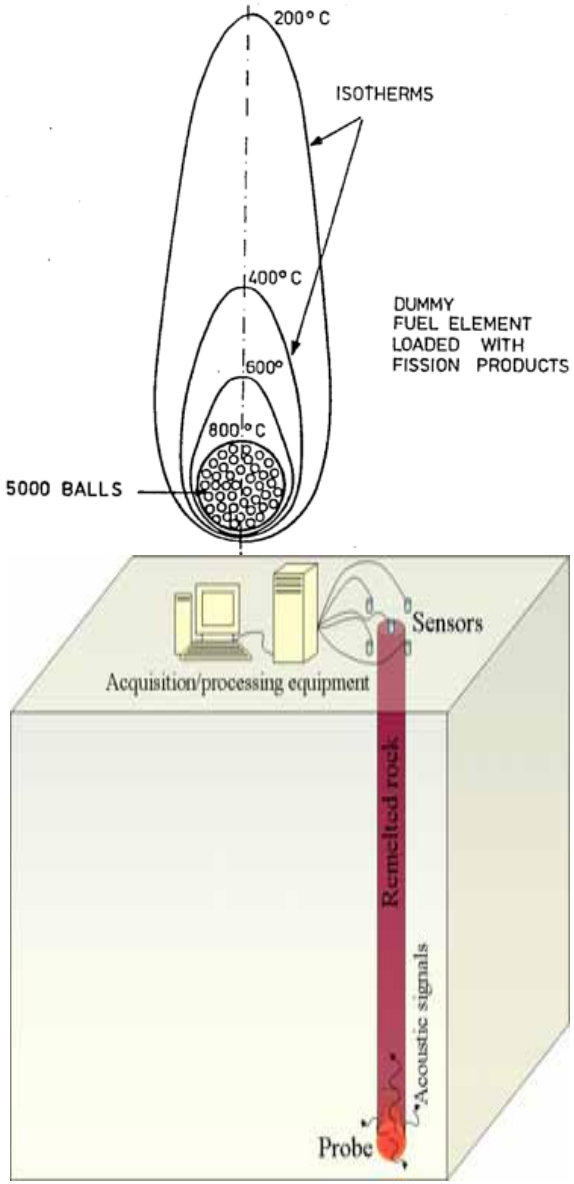
-Both S and Se are p-type semiconductors in solid and liquid phases

- $^{35}S$ is pure beta emitter with average decay energy of 53 keV and half-life of 87.3 days

- ~7% efficiency

-Scalable to $cm^3$ to get tens of mW power range

# Self-sinking capsules to investigate Earth's interior & dispose of radioactive waste, old idea renewed




Small (1-meter), spherical, heat-emitting capsules could reach depths **in excess of 100 km** below surface of both oceanic and continental crust.

Penetration of crust would be rapid (mantle in <2 years) and depths safe for waste disposal in mantle could be reached **in 35 years or less**.

**Acoustic signals** generated during melting & recrystallization of rocks through which probe descends could be detected at Earth's surface. These signals **could report on physical properties** of rocks & define mineralogical and chemical compositions and other properties of rocks. *Ojovan et al. 2011*

# Summary

- Unexploited applications abound
- Many due to advances in enabling technologies in materials, mfrg, IT, catalysts…
- Constrained by issues raised by other Teams (finance, regulation, social acceptance, habit, etc.)
- Consider outlier futures, including abundant electricity and heat if fortuitous confluence of several energy sources