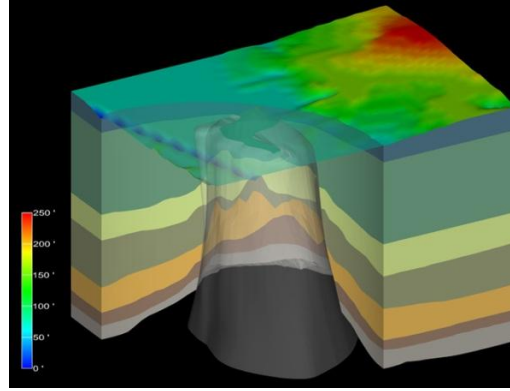


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Characterization of Deep Hydrogeology for Borehole Disposal of High-Level Radioactive Waste

NGWA Conference on Characterization of Deep Groundwater
May 8, 2014

Bill W. Arnold and W. Payton Gardner

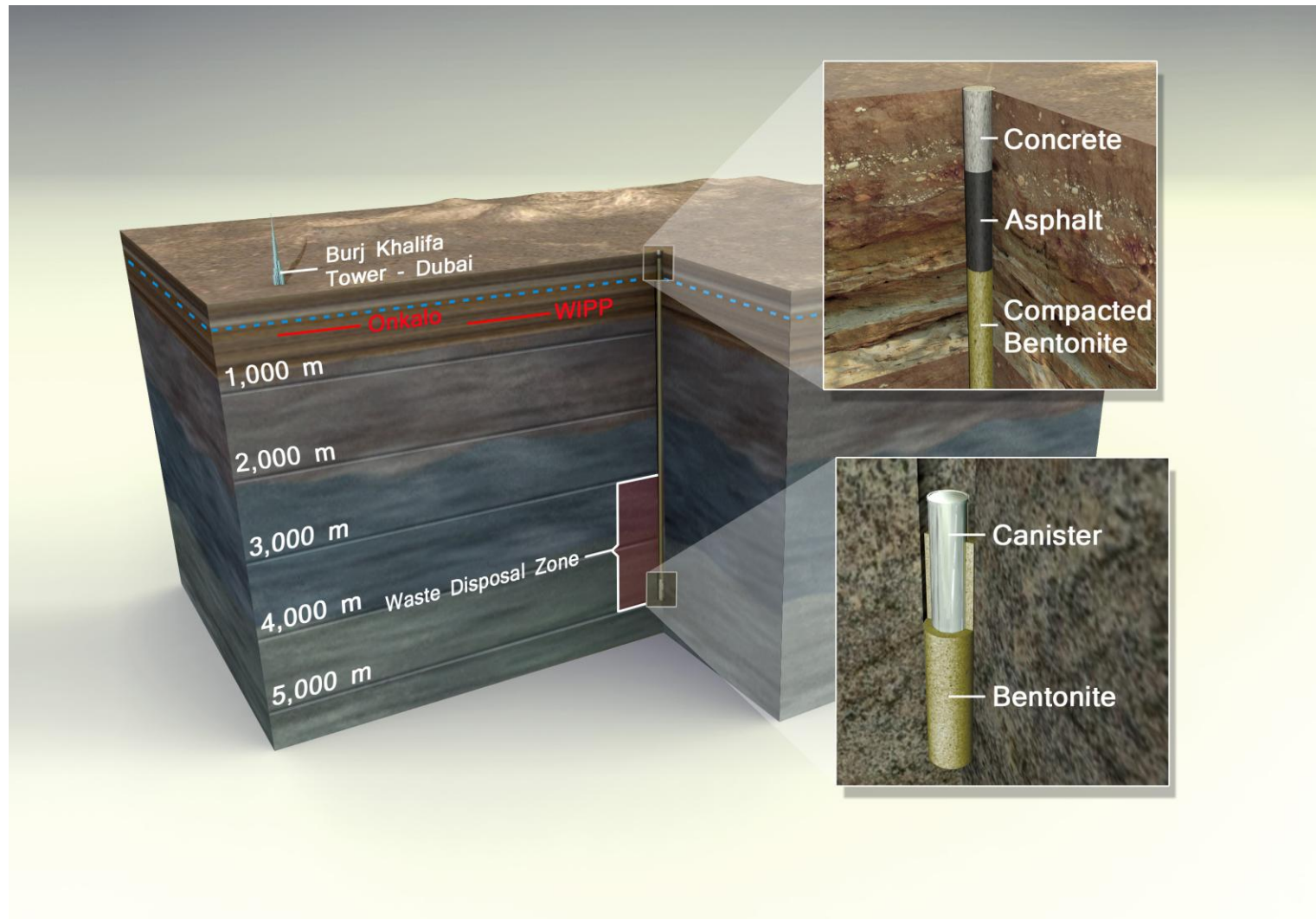
Outline

- **Deep borehole disposal concept**
- **Disposal concept viability and safety**
- **Deep hydrogeology characterization priorities**
- **Characterization challenges**
- **Conclusions**

Deep Borehole Disposal Concept

- Disposal concept consists of drilling a borehole or array of boreholes into crystalline basement rock to about 5,000 m depth
- Borehole casing or liner assures unrestricted emplacement of waste canisters
- Waste would consist of spent nuclear fuel and/or high-level radioactive waste
- Approximately 400 waste canisters would be emplaced in the lower 2,000 m of the borehole
- Upper borehole would be sealed with compacted bentonite clay , cement plugs, and cemented backfill

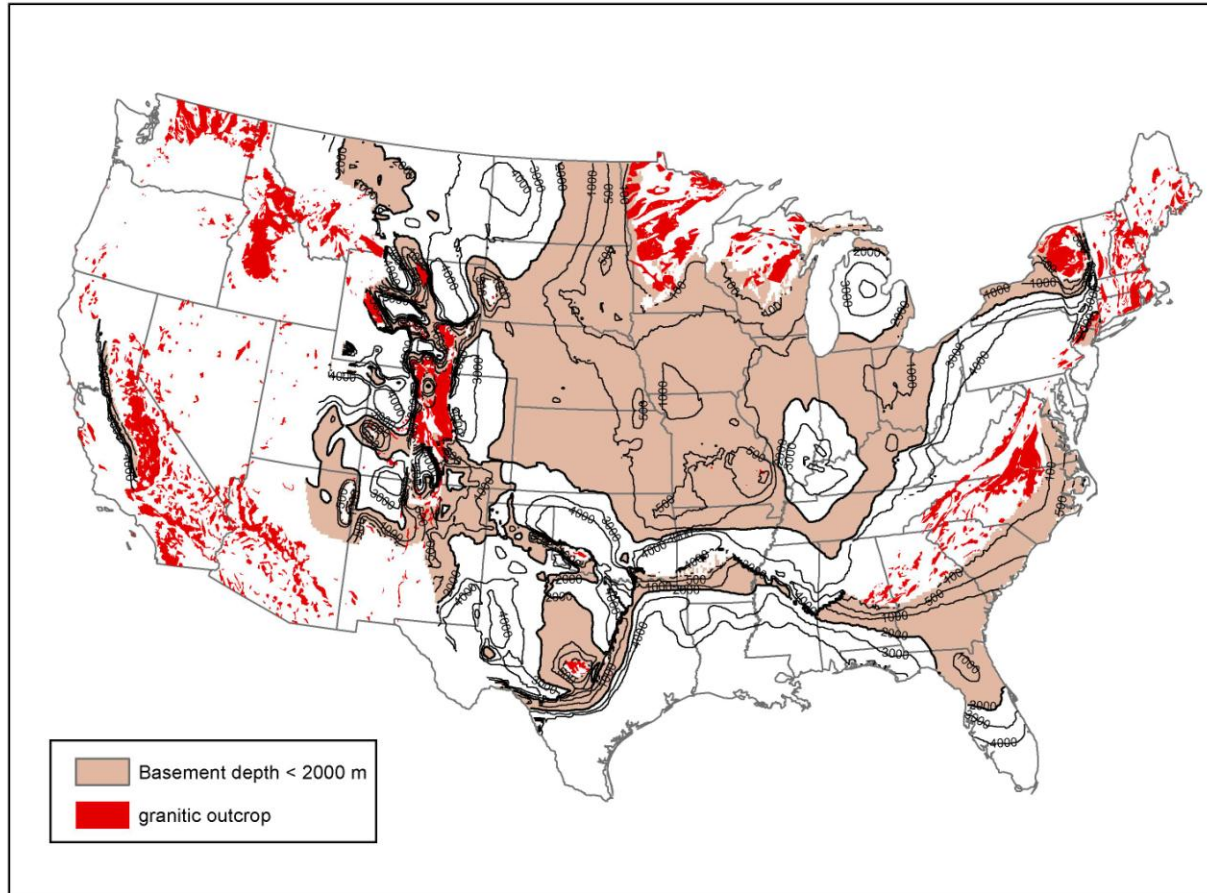
Deep Borehole Disposal Concept



Deep Borehole Disposal Concept: Viability and Safety

- **Crystalline basement rocks are common in many stable continental regions**
- **Existing drilling technology permits reliable construction at acceptable cost**
- **Low permeability and long residence time of high-salinity groundwater in deep continental crystalline basement at many locations suggests very limited interaction with shallow fresh groundwater resources**
- **Geochemically reducing conditions at depth limit the solubility and enhance the sorption of many radionuclides in the waste**
- **Density stratification of saline groundwater underlying fresh groundwater would oppose thermally induced groundwater convection**

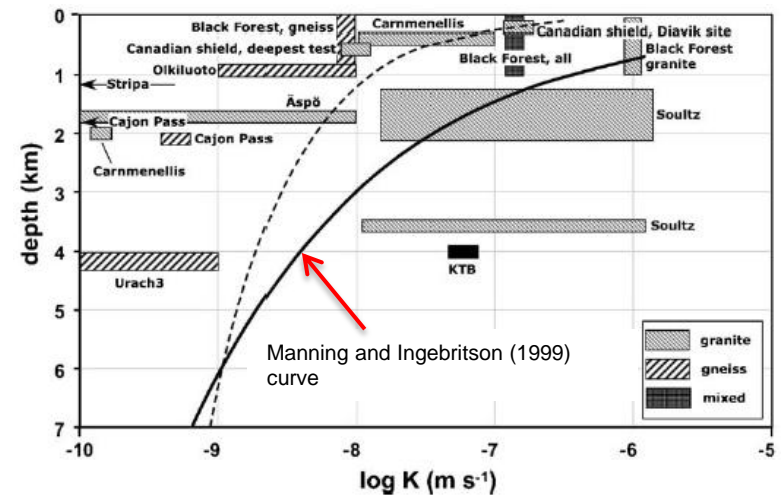
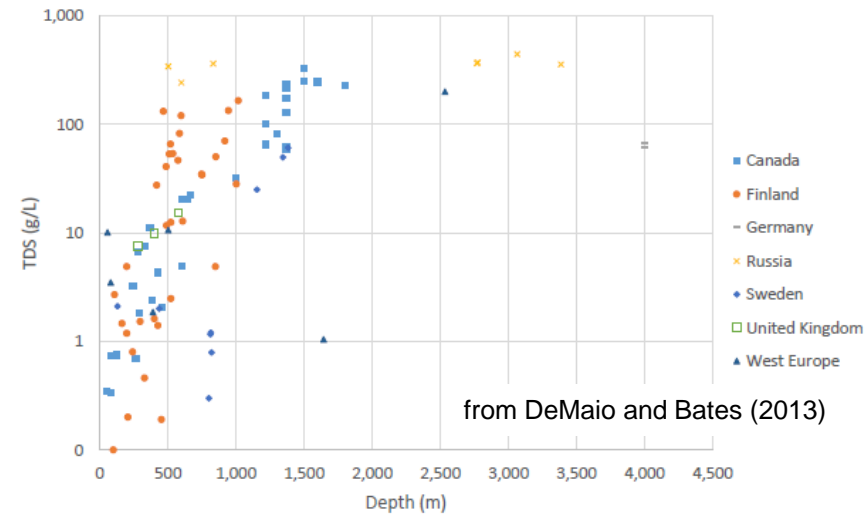
Disposal Concept Viability: Depth to Crystalline Basement



from Perry (2013)

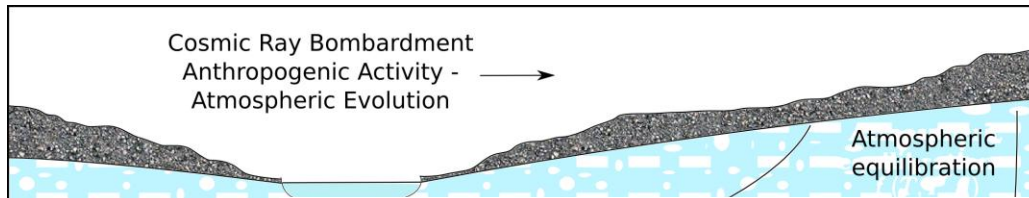
Characterization Priorities

- Groundwater age and history
- Groundwater salinity and geochemistry
- Potentially overpressured conditions
- Permeability in the host rock and disturbed rock zone near the borehole
- Chemical and mineralogical interactions with borehole seals



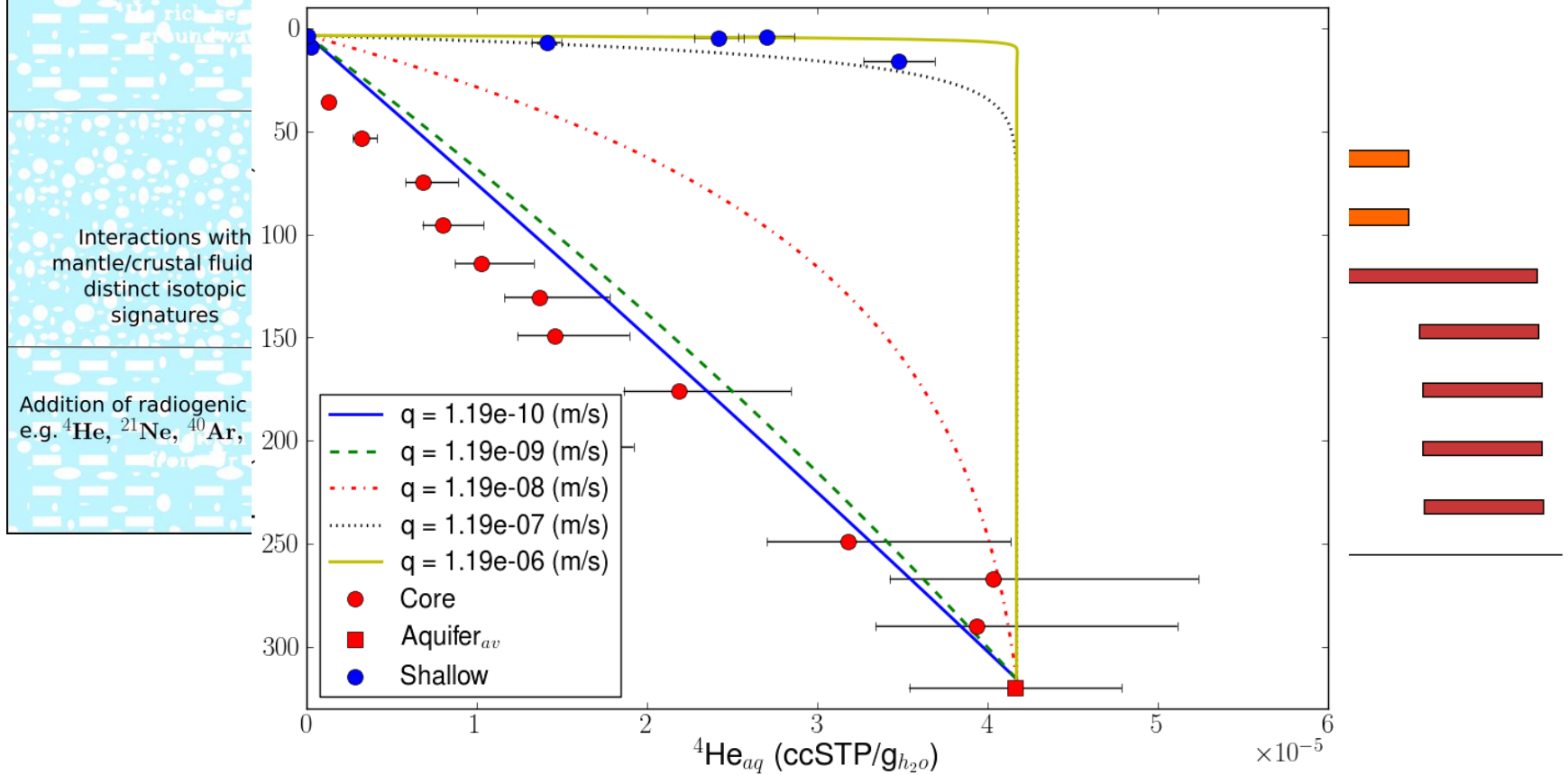
from Stober and Bucher (2007)

Fluid Age and History: Environmental Tracers



Tracer	Approximate Age Range Log Years Before Present							
	1	2	3	4	5	6	7	8

³²Si



Characterization Challenges

- **Identifying and sampling representative fluids in fractured, low-permeability crystalline rocks**
- **Accurately determining fluid potential as a function of depth to assess potentially overpressured conditions**
- **Characterizing the disturbed rock zone near the borehole**
- **Determining the long-term interactions between groundwater and borehole seals, and assessing the impacts on seals integrity**
- **Conducting logging and testing in large-diameter boreholes (17-inch diameter in reference design)**

Conclusions

- **Multiple factors indicate the feasibility and safety of the deep borehole disposal concept**
- **Demonstration site selection guidelines indicate that large areas with favorable geological characteristics exist in the conterminous U.S.**
- **Groundwater characterization should focus on aspects of the system critical to demonstrating safety of the deep borehole disposal system:**
 - **Groundwater age and history**
 - **Salinity and geochemistry**
 - **Potential for vertical fluid movement**
 - **Permeability in the host rock and disturbed rock zone**
 - **Borehole seals integrity and durability**