Exploring Bisulfide Transport through Bentonite Under Deep Geological Repository Conditions

Tarek Rashwan[1], Farhana Chowdhury[1], Sifat Papry[1], Mehran Behazin[2], Peter Keech[2], Pulin Mondal[1], Jitendra Sharma[1], and Magdalena Krol[1]

[1]York University
[2]Nuclear Waste Management Organization

November 23, 2022

Abstract

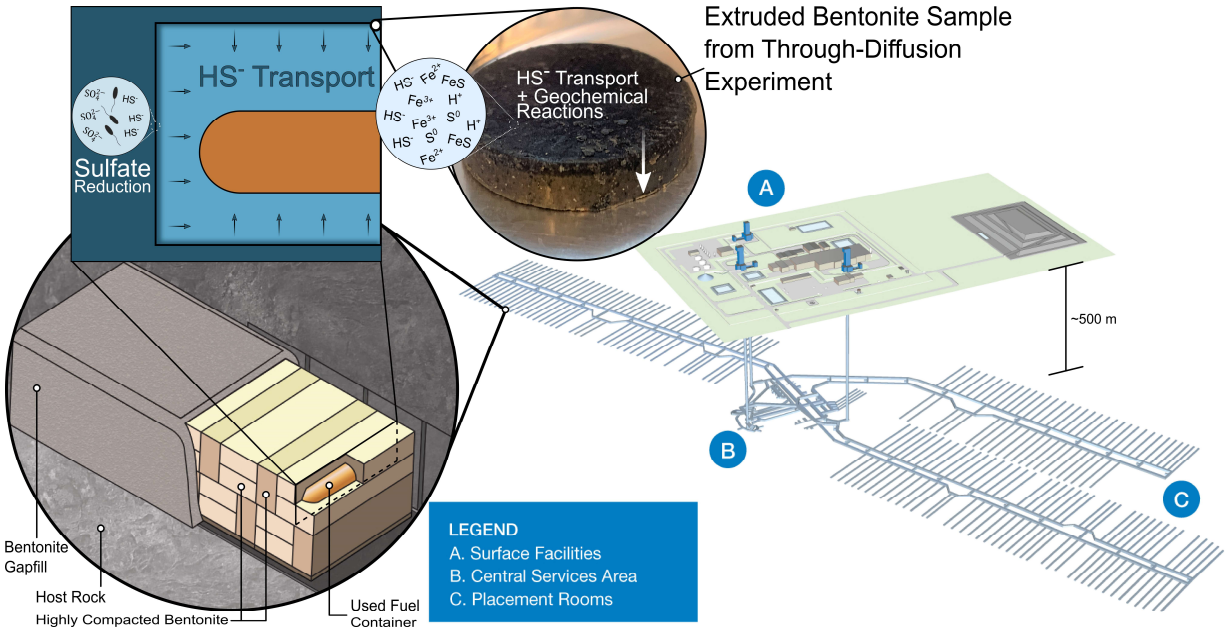
Management of used nuclear fuel is a major technical challenge faced by nuclear energy producing nations worldwide. In Canada, the Nuclear Waste Management Organization is responsible for the design and implementation of a deep geological repository (DGR), which will be placed ˜500 m below ground surface in a stable host rock to safely contain and isolate used fuel. Within a DGR, used nuclear fuel will be placed in used fuel containers (UFCs) that are encased in copper because of copper's corrosion resistance. The UFCs will be surrounded by highly compacted bentonite to suppress the transport of corrosive agents to the UFC and limit the movement of radionuclides out of a DGR in the unlikely case of a breach. Over the design lifespan of one million years for the DGR, it is possible that sulfate-reducing bacteria near the bentonite-host rock interface can produce bisulfide (HS^-) that can be transported to the UFC surface and potentially corrode the outer copper barrier. Therefore, it is crucial to understand HS^- transport mechanisms through bentonite to assess the long-term performance of a DGR. This study aims to quantify HS^- transport through bentonite using through-diffusion experiments under a range of anticipated DGR and bentonite conditions (e.g., temperature, ionic concentration, bentonite densities). In addition, as geochemical reactions/sorption are expected to affect HS^- transport, batch experiments are being conducted to understand these processes independent of transport. The preliminary batch of experimental results show that ˜85% of HS^- was partitioned from the aqueous to solid phase within first hour and ˜97% after 24 hours. However, this partitioning efficiency decreased with increased liquid-to-solid ratio because of the reduction in available reaction/sorption sites on the bentonite. This presentation shows the results from both transport and batch experiments performed on the bentonite under relevant DGR conditions.

Exploring Bisulfide Transport through Bentonite Under Deep Geological Repository Conditions

Tarek Rashwan[1], Farhana Chowdhury[1], Sifat Azad Papry[1], Mehran Behazin[2], Pete Keech[2], Pulin Mondal[1], Jitendra Sharma[1], and Magdalena Krol[1]

[1] Department of Civil Engineering, York University, 4700 Keele St., Toronto, ON M3J 1P3, Canada
[2] Nuclear Waste Management Organization, 22 St. Clair Ave. E, Toronto, ON M4T 2S3, Canada

Management of used nuclear fuel is a major technical challenge faced by nuclear energy producing nations worldwide. In Canada, the Nuclear Waste Management Organization is responsible for the design and implementation of a deep geological repository (DGR), which will be placed ~500 m below ground surface in a stable host rock to safely contain and isolate used fuel. Within a DGR, used nuclear fuel will be placed in used fuel containers (UFCs) that are encased in copper because of copper's corrosion resistance. The UFCs will be surrounded by highly compacted bentonite to suppress the transport of corrosive agents to the UFC and limit the movement of radionuclides out of a DGR in the unlikely case of a breach. Over the design lifespan of one million years for the DGR, it is possible that sulfate-reducing bacteria near the bentonite-host rock interface can produce bisulfide (HS^-) that can be transported to the UFC surface and potentially corrode the outer copper barrier. Therefore, it is crucial to understand HS^- transport mechanisms through bentonite to assess the long-term performance of a DGR. This study aims to quantify HS^- transport through bentonite using through-diffusion experiments under a range of anticipated DGR and bentonite conditions (e.g., temperature, ionic concentration, bentonite densities). In addition, as geochemical reactions/sorption are expected to affect HS^- transport, batch experiments are being conducted to understand these processes independent of transport. The preliminary batch of experimental results show that ~85% of HS^- was partitioned from the aqueous to solid phase within first hour and ~97% after 24 hours. However, this partitioning efficiency decreased with increased liquid-to-solid ratio because of the reduction in available reaction/sorption sites on the bentonite. This presentation shows the results from both transport and batch experiments performed on the bentonite under relevant DGR conditions.


HS⁻ Transport
Sulfate Reduction
HS⁻ Transport + Geochemical Reactions
Extruded Bentonite Sample from Through-Diffusion Experiment
A
B
C
~500 m
Bentonite Gapfill
Host Rock
Highly Compacted Bentonite
Used Fuel Container
LEGEND
A. Surface Facilities
B. Central Services Area
C. Placement Rooms