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Nuclear Wasteform and Barrier Matrixes Interaction with Geologic Strata in the Subsurface of the Yamin Plateau, Northern Negev, Israel

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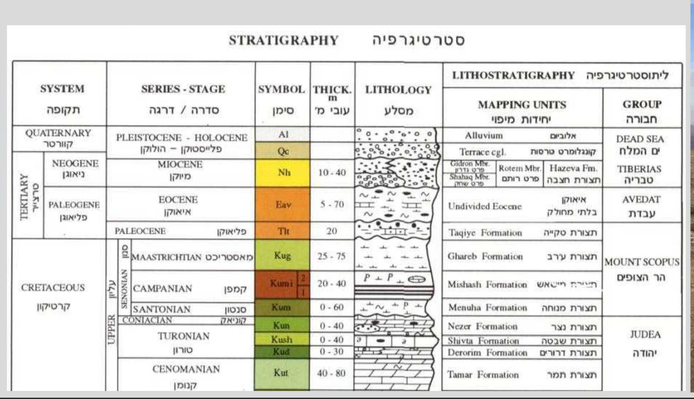
Background

- Designing and implementing a nuclear waste repository in the subsurface of the Yamin Plateau, Northern Negev, Israel is a complicated task because of lack of common target rock formations for geologic disposal.
- To determine a possible disposal site, it is important to characterize interactions of cementitious materials with available carbonate rock strata.
  - Cement is widely used as a component in disposal systems.
  - Six representative rock types and two cement types are being used.
- This project is a part of a bi-national collaboration between Vanderbilt University, Sandia National Laboratories, Ben Gurion University and the Nuclear Research Center of the Negev (NRCN), Israel.



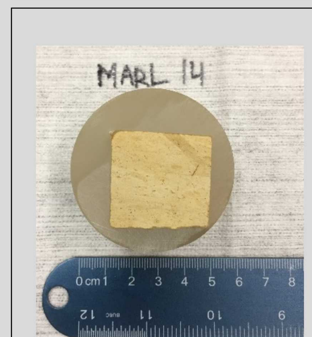
Objectives

- Characterize cement barrier and carbonate rock interactions and radionuclide transport across interfaces.
- Perform reactive transport and equilibrium testing.
- Develop geochemical simulations of cement-rock interactions.

Methods

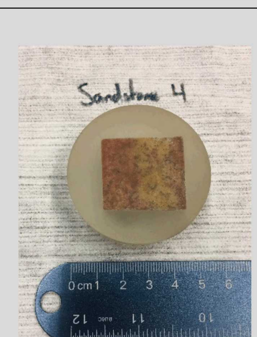
- Host Rock Characterization
  - Pore water chemistry, constituent diffusivity and leaching properties of the host rocks using EPA Methods 1313, 1315, 1316.
  - Specific surface area, pore size distribution and porosity using nitrogen gas adsorption (BET) and mercury intrusion porosimetry (MIP).
  - Mineral phases using X-Ray diffraction (XRD).
  - Microstructural analysis using petrographic microscope and scanning electron microscopy images.

Materials



Marl

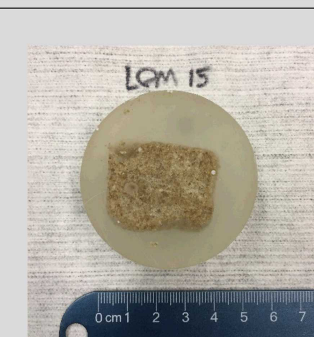
Chalk



Sandstone

Oil Shale

Phosphorite (H)



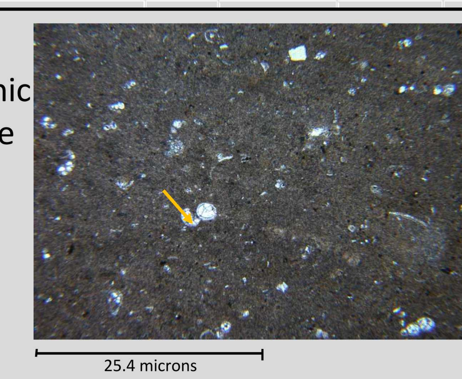
Phosphorite (L)

Preliminary Results

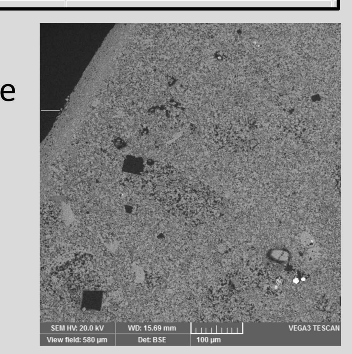
BET, MIP, and Imaging of Samples – SNL Summer 2018

Rock	BET Surface Area (m^2/g)	Porosity (%)	Average Pore diameter (um)	Total Pore Area (m2/g)	Total Intrusion Volume (mL/g)	Bulk density (g/mL)	Tortuosity (Calc)	Cumulative Pore Volume (mL/g)
Sandstone	0.4926	8.2597	0.3953	0.345	0.0341	2.4201	26.9447	0.0314
Marl	5.5523	31.6708	0.13764	4.983	0.1715	1.8471	87.5473	0.1318
Chalk	0.6428	6.8169	0.10467	1.056	0.0276	2.4672	67.6575	0.253
Phosphorite	15.0786	34.8568	0.03646	26.415	0.2408	1.4476	4.3768	0.121
Oil Shale	15.9254	32.8374	0.02751	25.318	0.1741	1.8858	64.966	0.1018

Marl Petrographic Microscope Image

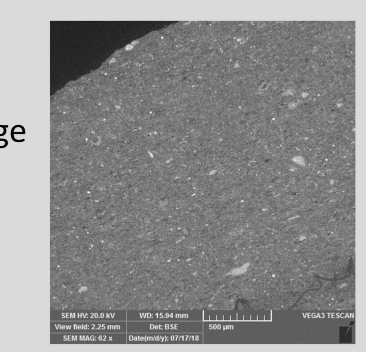


Marl SEM Image

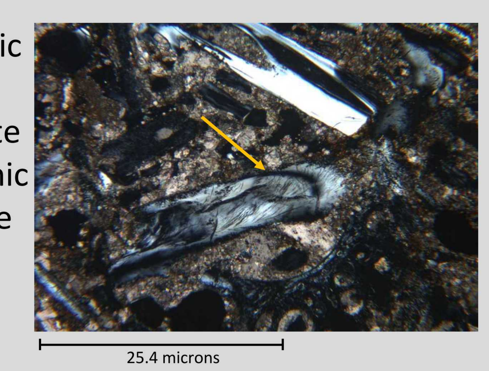


Oil Shale Petrographic Microscope Image

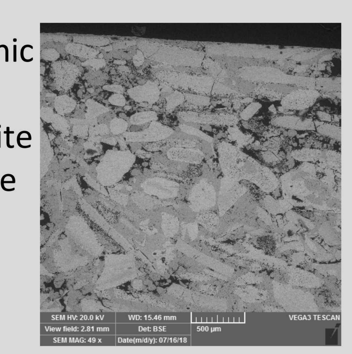
Oil Shale SEM Image



Low Organic Matter Phosphorite Petrographic Microscope Image



Low Organic Matter Phosphorite SEM Image



XRD (wt%) – NRCN Spring 2018

	Chalk	Marl	Low Organic Matter Phosphorite	High Organic Matter Phosphorite	Sandstone	Oilshale
Quartz	0.5	1	0.5	0.5	67	4
Calcite	99.5	95	35.5	25.5	33	75
Fluorappatite	-	-	64	74	-	7
Kaolinite	-	3	-	-	-	9
NaCl	-	1	-	-	-	-
Gypsum	-	-	-	-	-	5

Summary Table:

Sample #	Dominant	Major	minor	Minor-trace	Trace
SANDSTONE		Iilitic I-S (r) Kaolinite	Illite		Chlorite Quartz K-feldspar
MARL	I-S (r)			Kaolinite	Illite Quartz Goethite
HOM PHOSPH	Poor quality analysis – the sample contained very small amount of clay-size material. Includes illitic I-S (r), kaolinite, quartz and possibly gypsum.				
LOM PHOSPH	I-S (r)			Palygorskite	Quartz K-feldspar Calcite
CHALK	Not enough clay-size material for analysis				
OIL SHALE	Organic matter prevented equal dispersion and flattening of clays over the glass slide – sample could not be analyzed				

Dominant >50%, Major =20-50%, Minor =5-20%, Trace <5%. Abbreviations: I-S – Interlayered illite-smectite, (r) – randomly ordered.

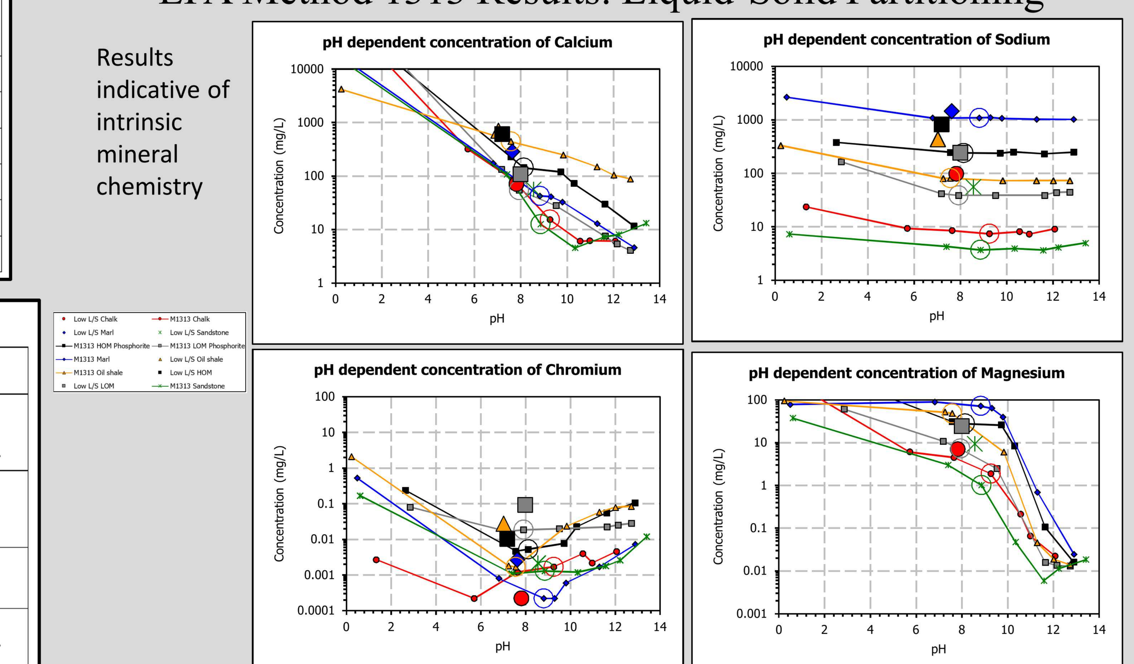
Pictured left: Test apparatus set up designed for EPA Method 1315.

Below: Post 1315 leaching test sample preparation for post-test analysis.

EPA Method 1313, 1315 – Vanderbilt, On Going

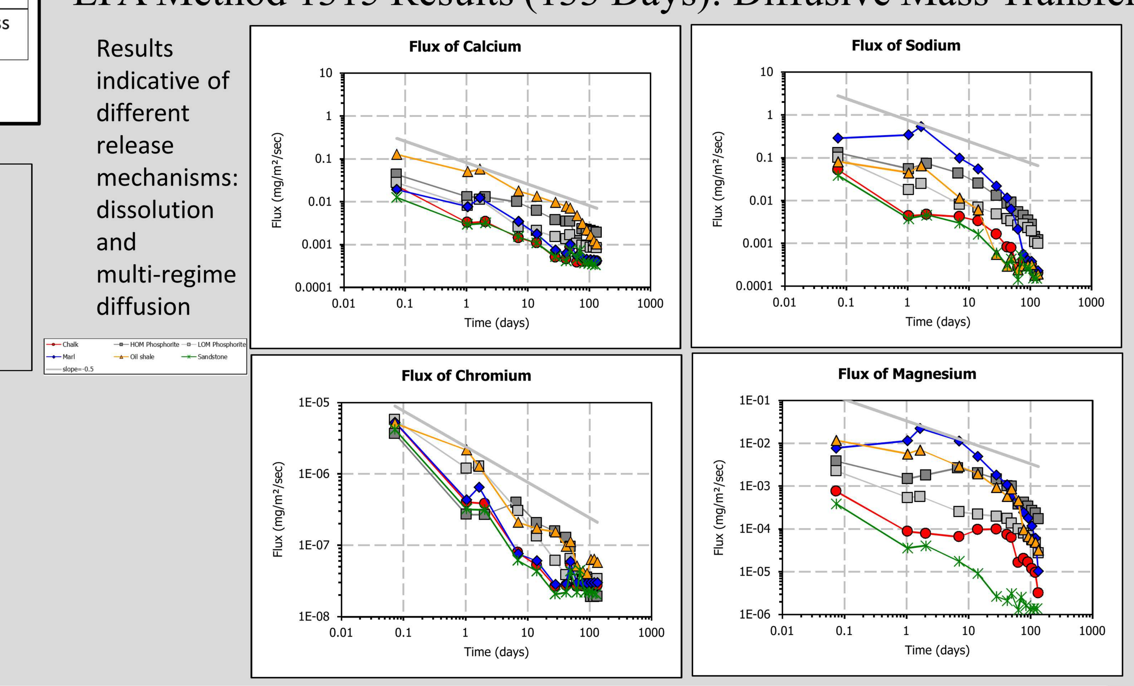
EPA Method 1313 Results: Liquid-Solid Partitioning

Results indicative of intrinsic mineral chemistry



EPA Method 1315 Results (133 Days): Diffusive Mass Transfer

Results indicative of different release mechanisms: dissolution and multi-regime diffusion



Conclusions and Future Research

- This work offers baseline data and basic insights to the chemistry and composition of potential host rocks for geologic disposal of nuclear waste forms.
- Data gathered from these preliminary tests can be used as inputs to modeling programs to compare and validate the diffusive and reactive transport behavior of material constituents and radionuclides under baseline conditions.
- Further testing includes:
  - SEM analysis of current samples that have undergone 1315 test with LiBr tracer to determine ingress front.
  - Cement leaching tests. Two cement types have been cast (as of 09/18/18) and are undergoing a curing period before 1313 and 1315 tests are completed.
  - Geochemical modeling of host rock diffusive transport activity.

Acknowledgements and Disclaimer

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