Preliminary Study of Strong-Sludge Gas Retention and Release Mechanisms in Clay Simulants

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Pacific Northwest NATIONAL LABORATORY

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MISSION DRIVERS & BENEFITS[1]

Retrieve waste in Hanford SSTs and transfer to DSTs to reduce risk of future leaks.

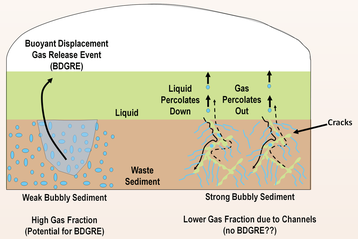
Space exists in DSTs but can't be used due to criteria to avoid buoyant displacement gas release events (BDGREs).

- In 2018, SST retrievals will start being delayed.
- Retrievals can resume only when the Waste Treatment and Immobilization Plant reduces waste inventory.

Relaxing BDGRE controls avoids expense of building new DSTs.

- Could allow 2 to 3 million gallons of existing DST space to be used.
- Recent cost estimate is $88M per new DST (~ 1 million gallons).

RELEASE MECHANISMS

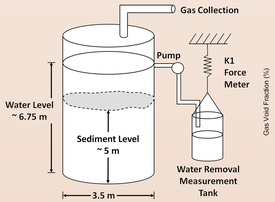


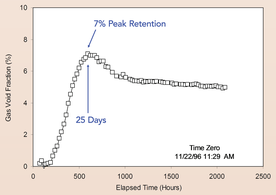
OBJECTIVES

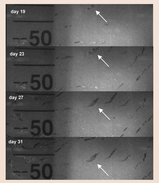
The objective is to conduct parametric studies to quantify when high-strength waste (~ 1000 Pa) results in low gas retention.

- A previous large-scale test observed relatively low gas retention (7% maximum gas void fraction) in comparison to previous small-scale Hanford studies.
- The single previous large-scale test did not systematically examine the dependence on shear strength, gas generation rate, and vessel size (self weight).

PREVIOUS LARGE-SCALE TEST IN KETELMEER SLUDGE[2,3]

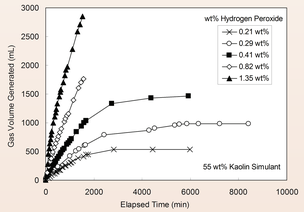


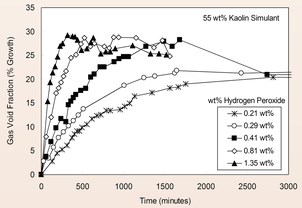




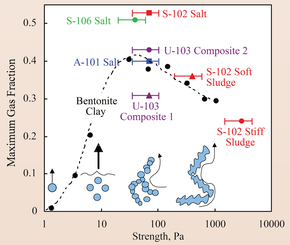
EXPERIMENTAL METHOD

- Load 5 in. ID columns with kaolin simulant with a range of strengths.
- Generate gas bubbles via decomposition of H_2O_2.
- Measure increase in clay height, water height, and total generated gas.
- Observe bubble shapes and crack formation.
- Calculate volume fraction of retained gas.





PREVIOUS SMALL-SCALE HANFORD TESTS[4]



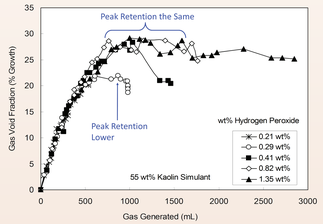
References

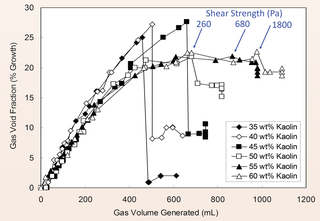
1. Meacham, JE. 2010. *Gas Retention and Release from Hanford High Shear Strength Waste.* RPP-RPT-26836, Rev. 0., Washington River Protection Services LLC, Richland, Washington.
2. van Kessel, T, and WGM van Kesteren. 2002. "Gas Production and Transport in Artificial Sludge Depots." Waste Management 22: 19–28.
3. Cornelisse JM. 1997. Measurement Report of the Large-Scale Laboratory Experiment on Sediment from Lake Ketelmeer with Artificial Gas Production. Technical Report DM13, Delft Hydraulics, Netherlands (in Dutch).
4. Rassat SD, SM Caley, PR Bredt, PA Gauglitz, DE Rinehart, and SV Forbes. 1998. Mechanisms of Gas Bubble Retention and Release: Experimental Results for Hanford Single Shell Waste Tanks 241-A-101, 241-S-106, and 241-U-103. PNNL-11981, Pacific Northwest National Laboratory, Richland, Washington.

EFFECT OF GAS GENERATION RATE AND SHEAR STRENGTH

Comparing gas retention as a function of gas volume generated, rather than time, allows experiments with different gas generation rates to be compared.

Results show some indication of lower gas generation rate giving lower retention and essentially no role of simulant shear strength when above a few hundred Pa.

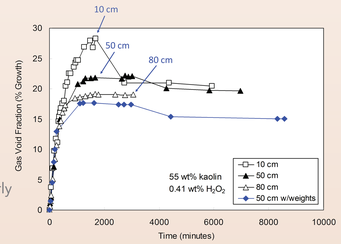


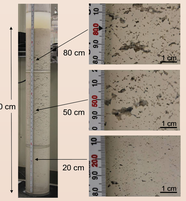


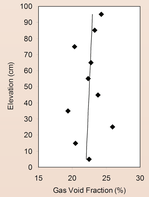
EFFECT OF SEDIMENT DEPTH AND EXTRAPOLATION TO DEEPER COLUMNS

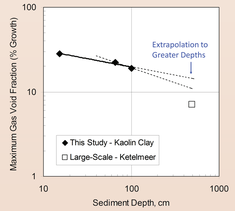
Gas retention decreased with increasing sediment depth in a series of tests. Bubble shapes appeared different towards the bottom of an 80 cm test, but the void fraction was nearly constant with depth.

These tests used a 680 Pa kaolin simulant.









Conclusions

- Gas retention decreased with increasing sediment depth for tests with 0.1 to 1 m deep layers using a 680 Pa kaolin simulant.
- Slower gas generation may cause lower retention.
- No apparent role of simulant strength for kaolin simulants between 260 - 1800 Pa for tests with initial sediment depth of 0.1 m.
- Gas retention in these intermediate size tests is larger than the single large-scale test in Ketelmeer sludge.

Future Direction

Conduct experiments with greater sediment depths and vessel diameters and with lower gas-generation rate

- quantify trend towards lower gas retention for progressively larger experiments

Develop slower gas generation method suitable for large-scale tests

- Biogenetic nitrogen generation

Once parameter region for low gas retention determined

- Confirm key mechanisms
- Compare with existing models and modify if needed
- Develop criteria for application to Hanford waste tanks

Contact Information

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