WM Symposia 2013

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Performance Impact of Fast Flow Paths Through Grout Monoliths Used for Radioactive Waste Disposal – 13224

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Session #36

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Overview

- **Key Concern:** Fast pathways (e.g., annuli, shrinkage gaps at grout flow lobe and lift interfaces, cracks and faults) through grout could allow rapid transfer of water to the contaminated zone at the base of WIR tanks
- **Project Purpose:** Develop insights into risk-significant aspects of grout properties and behavior affecting performance in stabilizing WIR tank waste; provide an improved technical basis for evaluating performance assessments and monitoring activities
- **Scope:** Perform experiments to evaluate *temporal evolution* of grout properties as WIR-like grouts cure and mature:
  - Grout shrinkage at flow lobe boundaries
  - Annulus apertures around steel tank liners, pipes, cooling coils, etc.
  - Crack growth
  - Bulk permeability

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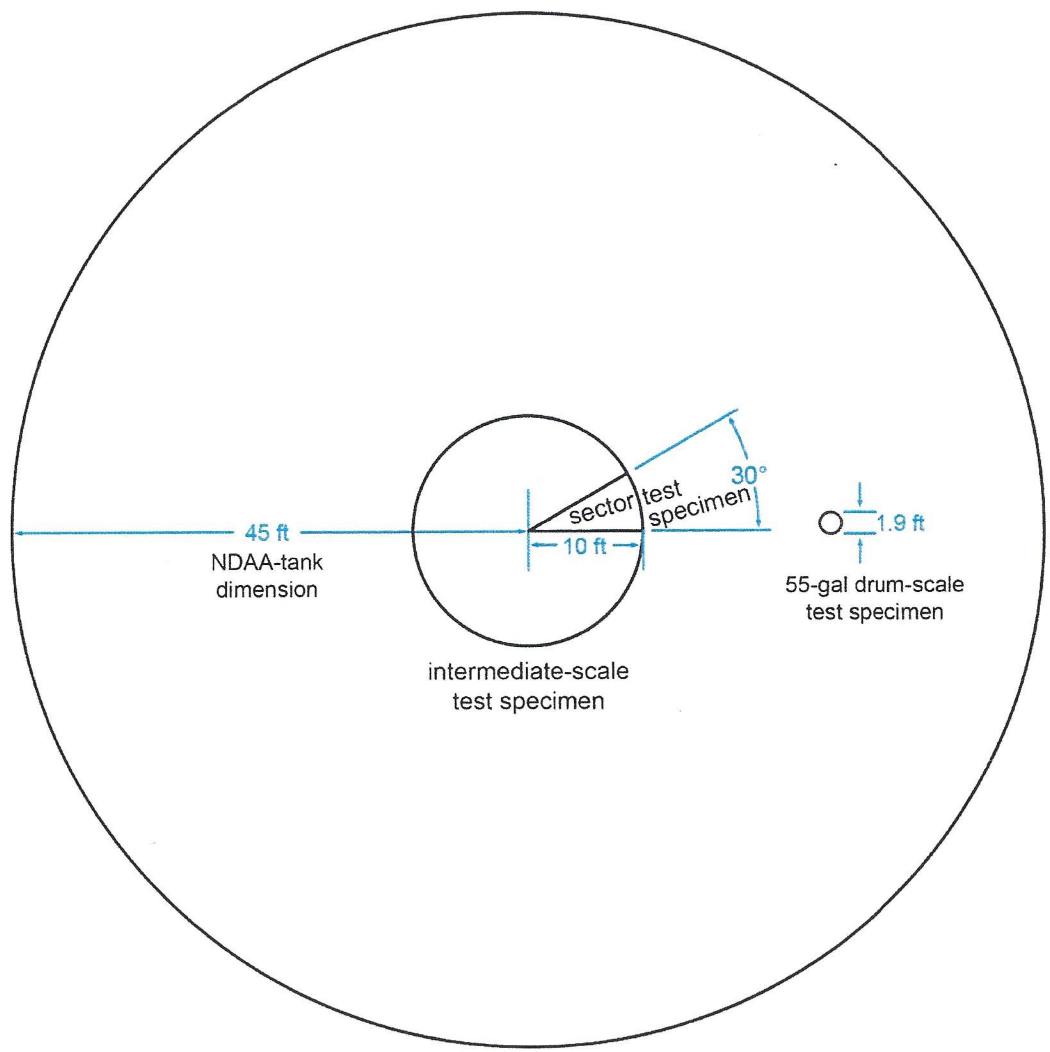
Grout Monolith Specimen Dimensions



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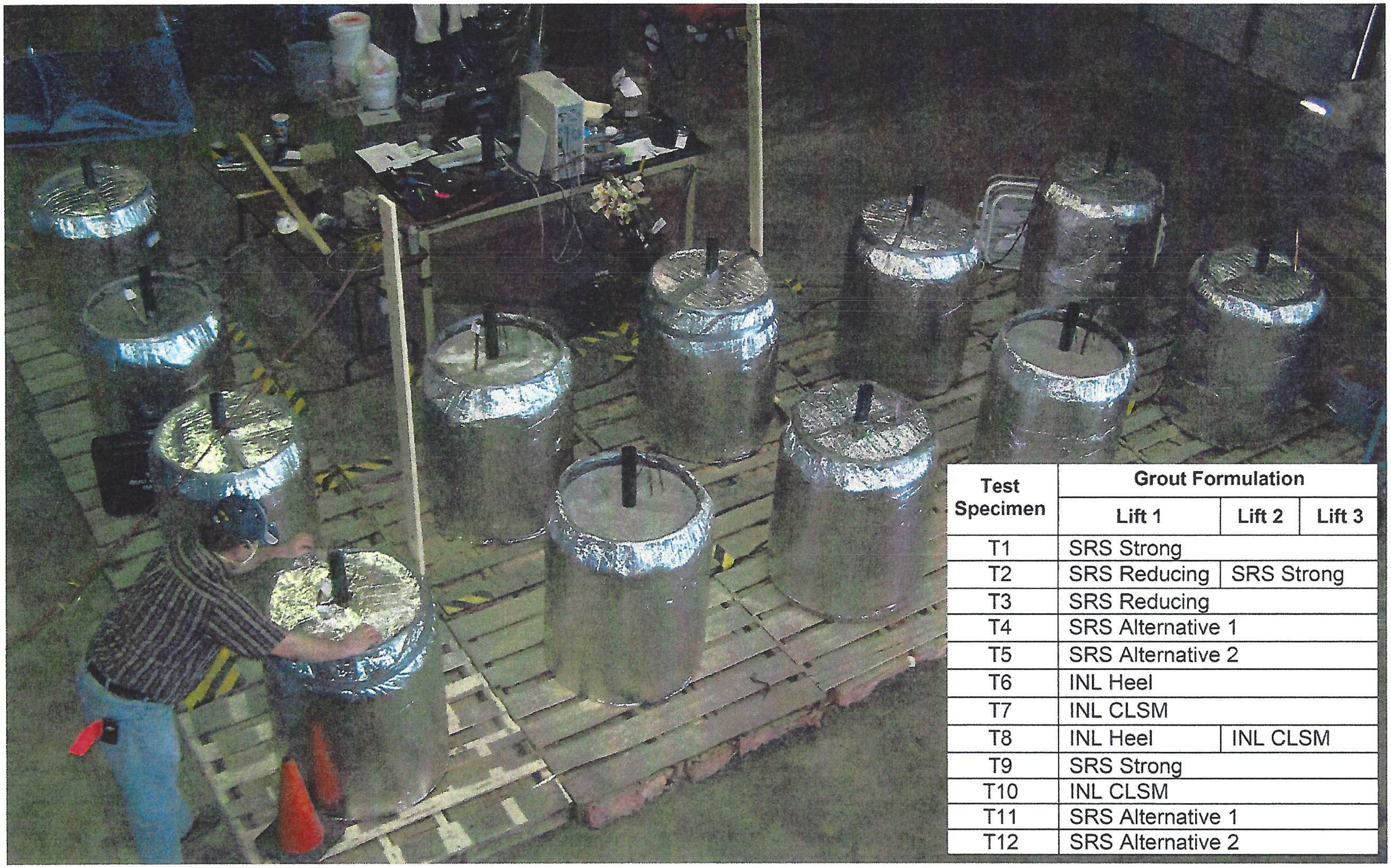
55-Gallon Drum Specimens



Test Specimen	Grout Formulation		
	Lift 1	Lift 2	Lift 3
T1	SRS Strong		
T2	SRS Reducing	SRS Strong	
T3	SRS Reducing		
T4	SRS Alternative 1		
T5	SRS Alternative 2		
T6	INL Heel		
T7	INL CLSM		
T8	INL Heel	INL CLSM	
T9	SRS Strong		
T10	INL CLSM		
T11	SRS Alternative 1		
T12	SRS Alternative 2		

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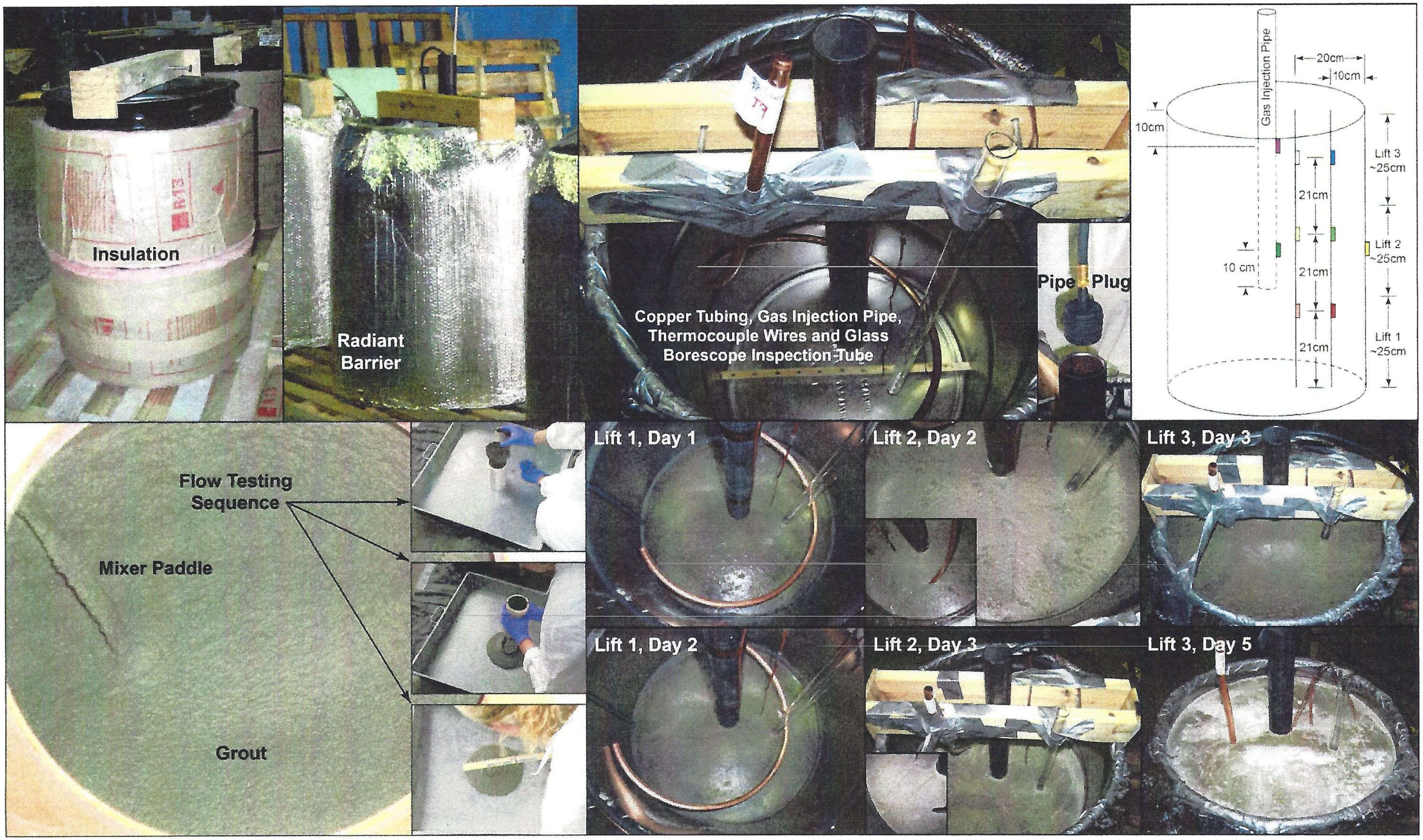
Drum Grout Specimen Preparation



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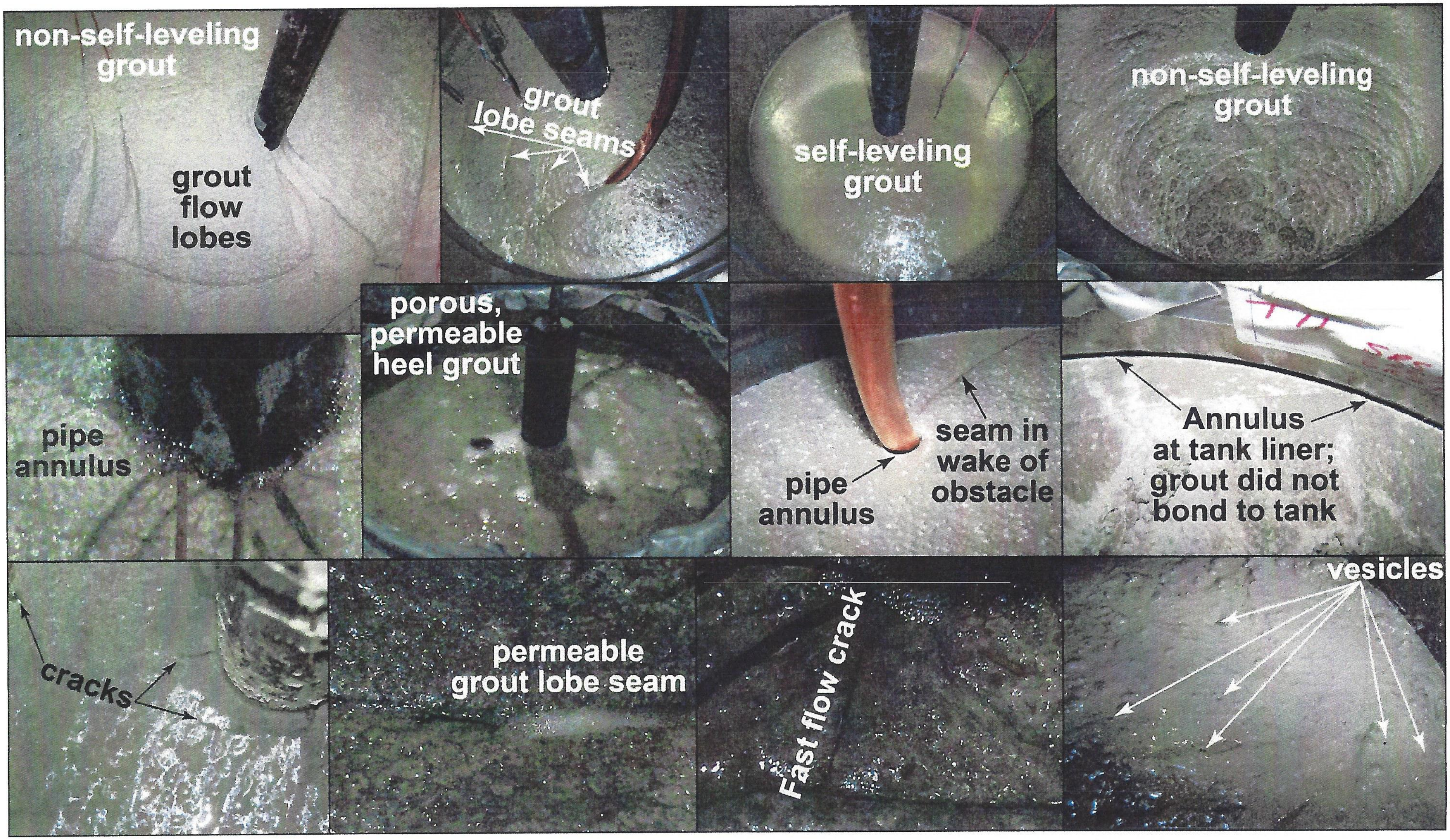
Grout Surface Features



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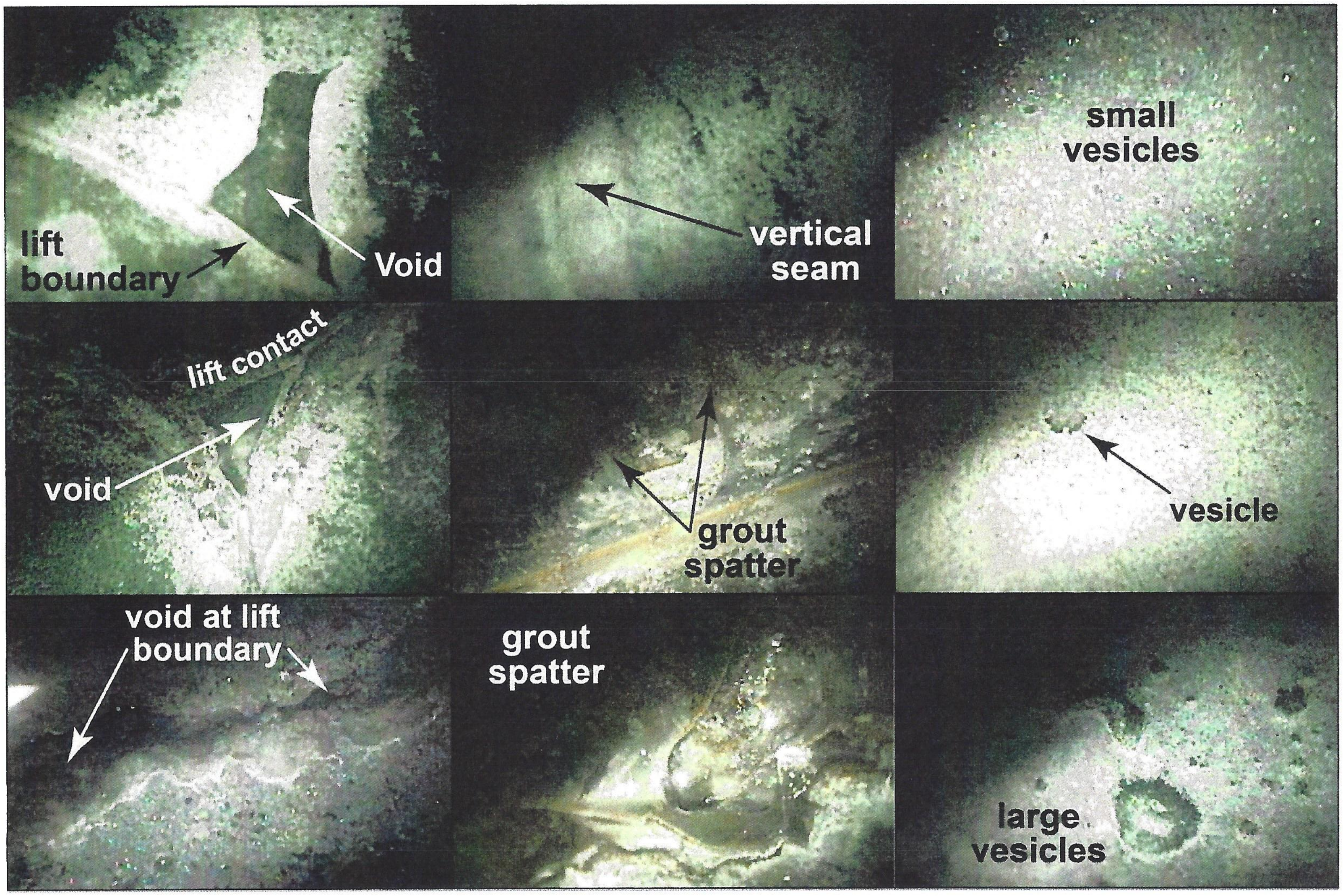
Borescopic Observations



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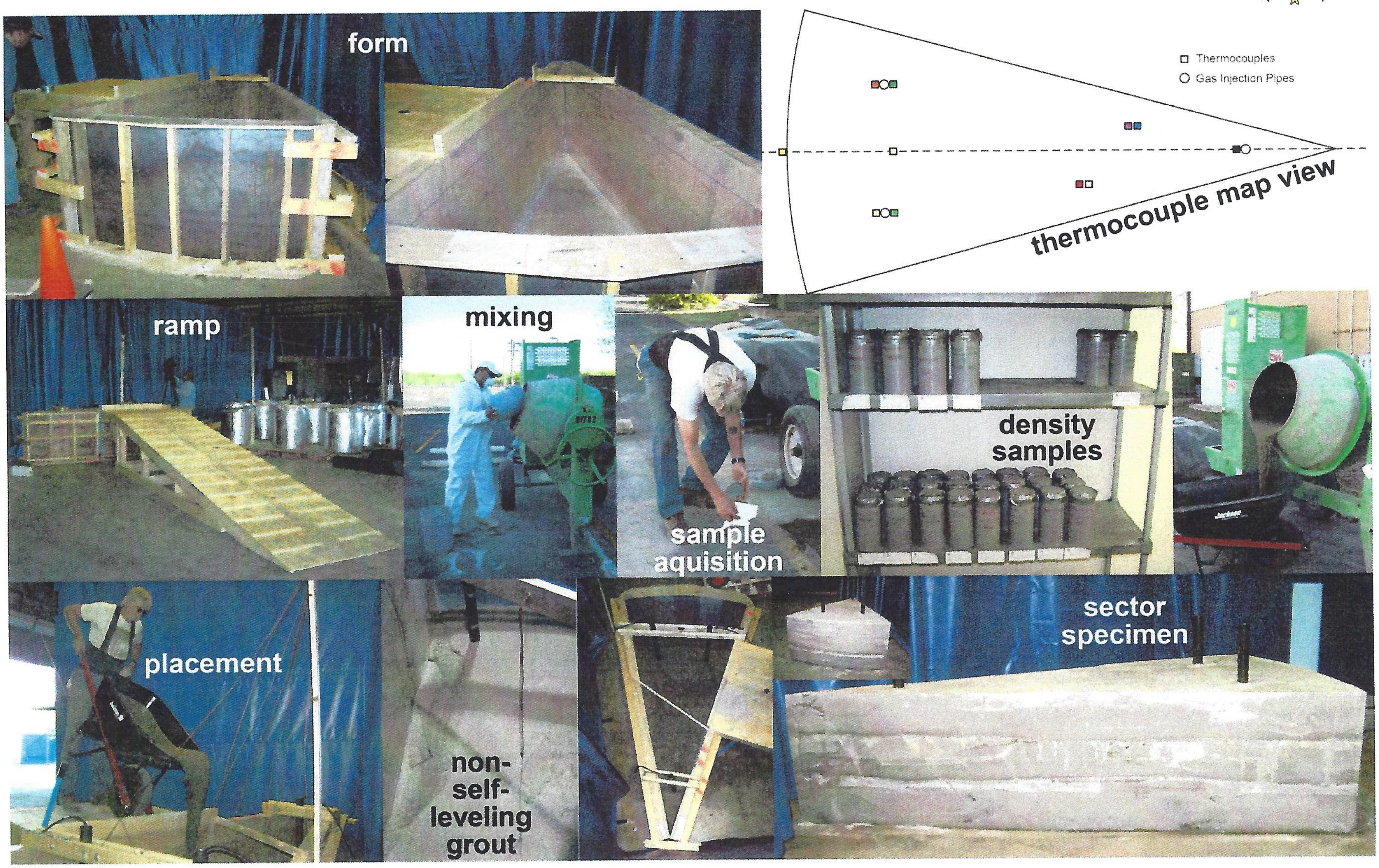
Sector Grout Specimen Preparation



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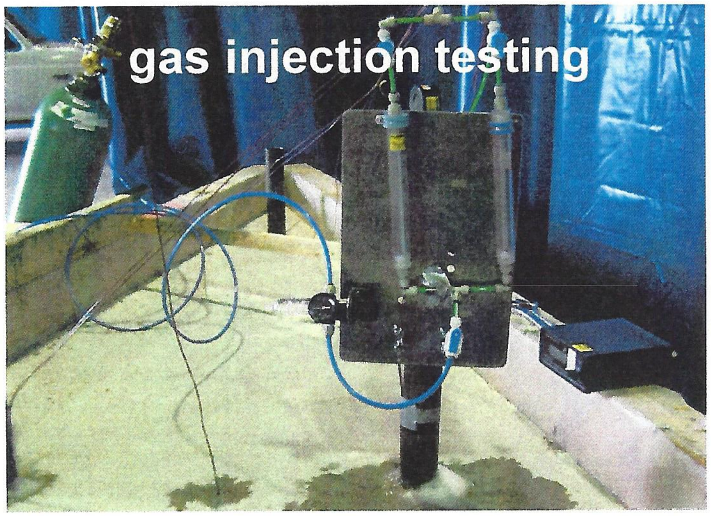
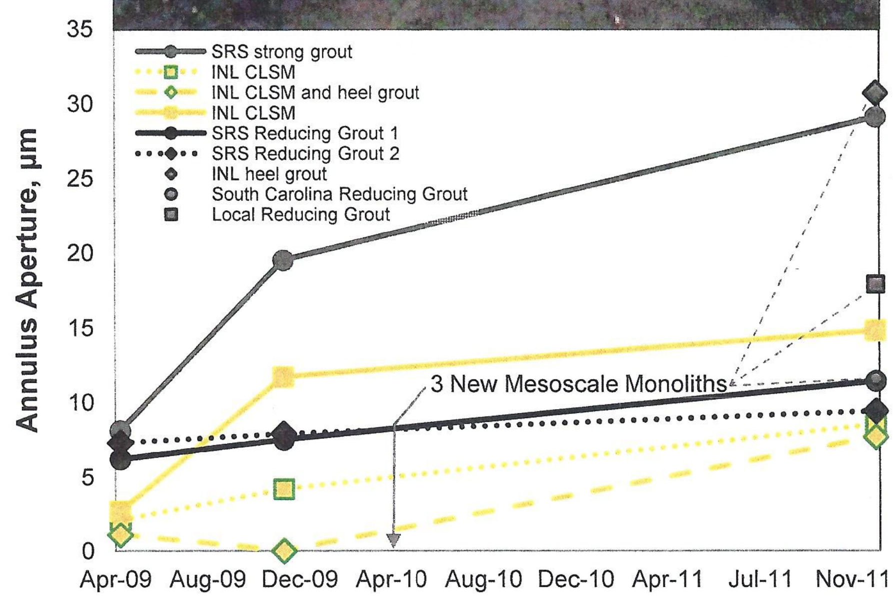
Evolution of Pipe Annulus Apertures



- Annuli surrounding embedded objects are fast flow paths that generally increased in size with time post-placement
- Grout formulation and monolith scale play significant roles in determining the sizes of annuli



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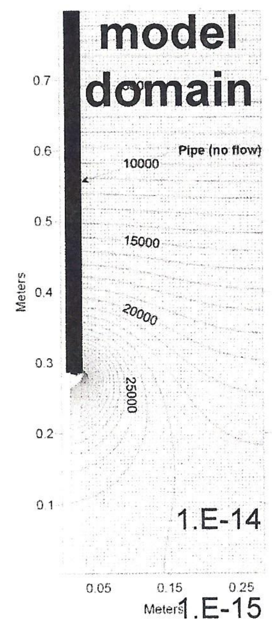
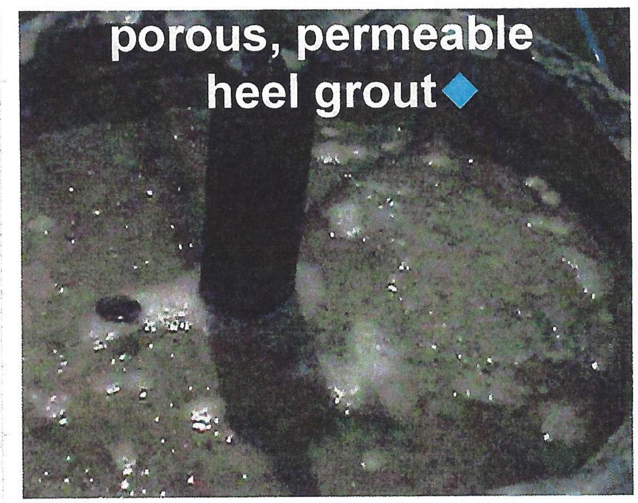
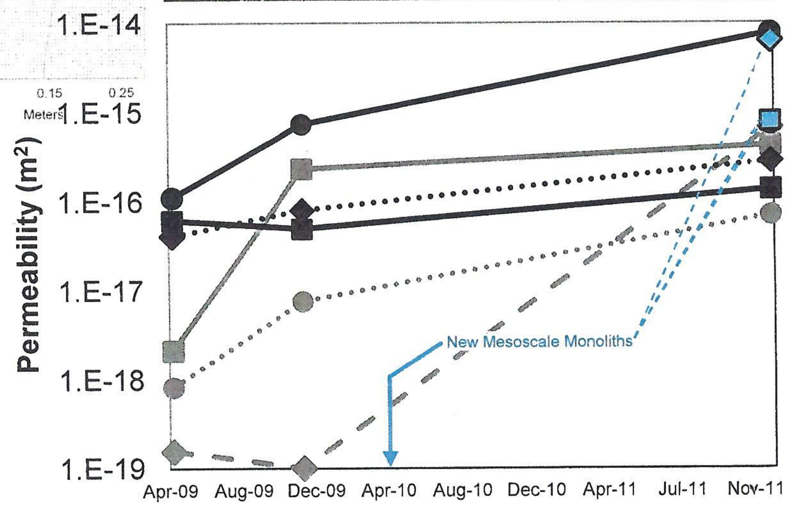
Evolution of Bulk Permeability

- Delayed microcracking and drying shrinkage occurred in some specimens
- Gas flow observed through cracks and grout lobe seams, in addition to flow through porous and permeable surfaces
- Bulk grout permeability generally increased with time post-placement due to microcracking and shrinkage at
  - Grout lobe seams
  - Lift interfaces







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Intermediate-Scale Alternative 1 Reducing-Grout Specimen: Preparation & Observations

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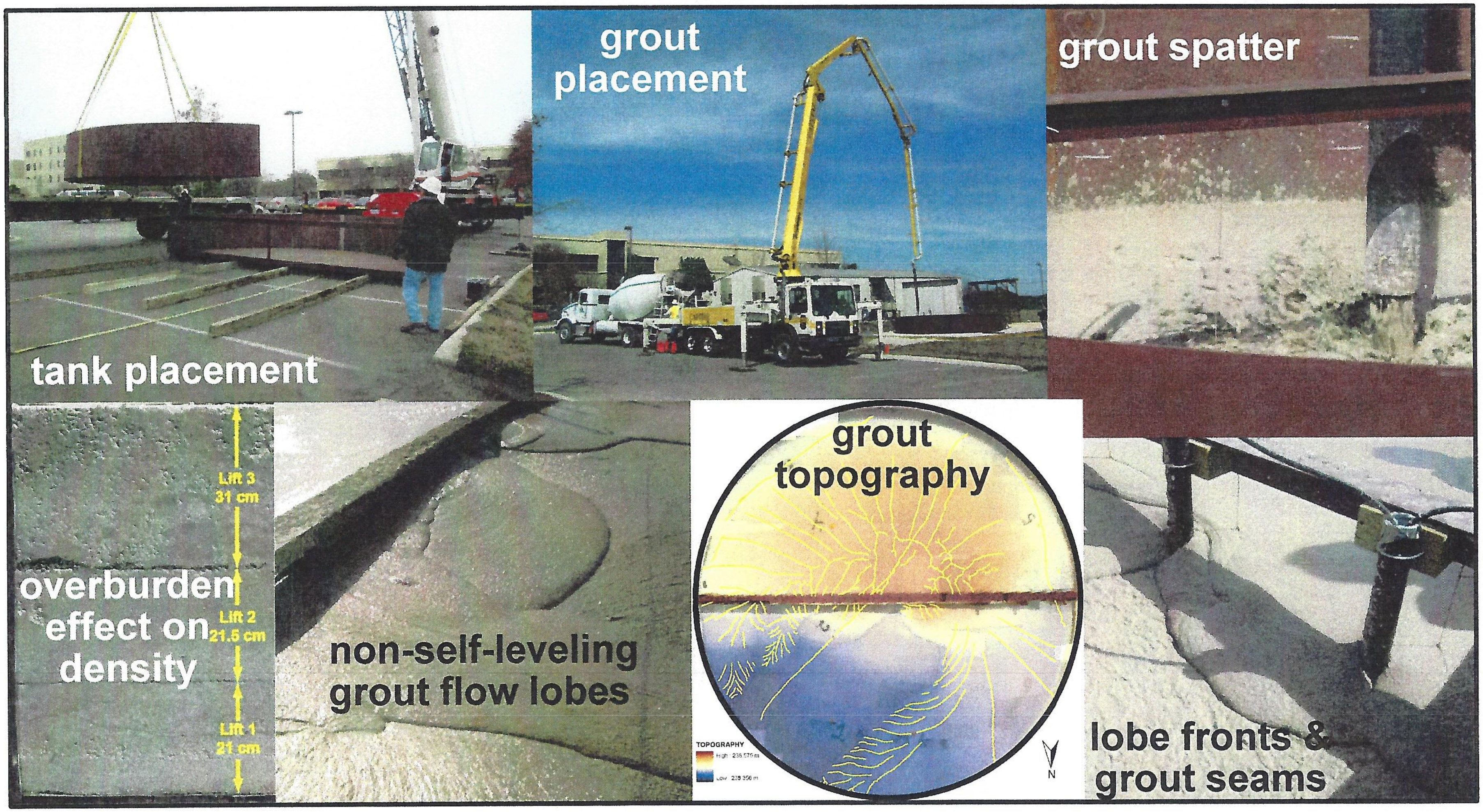

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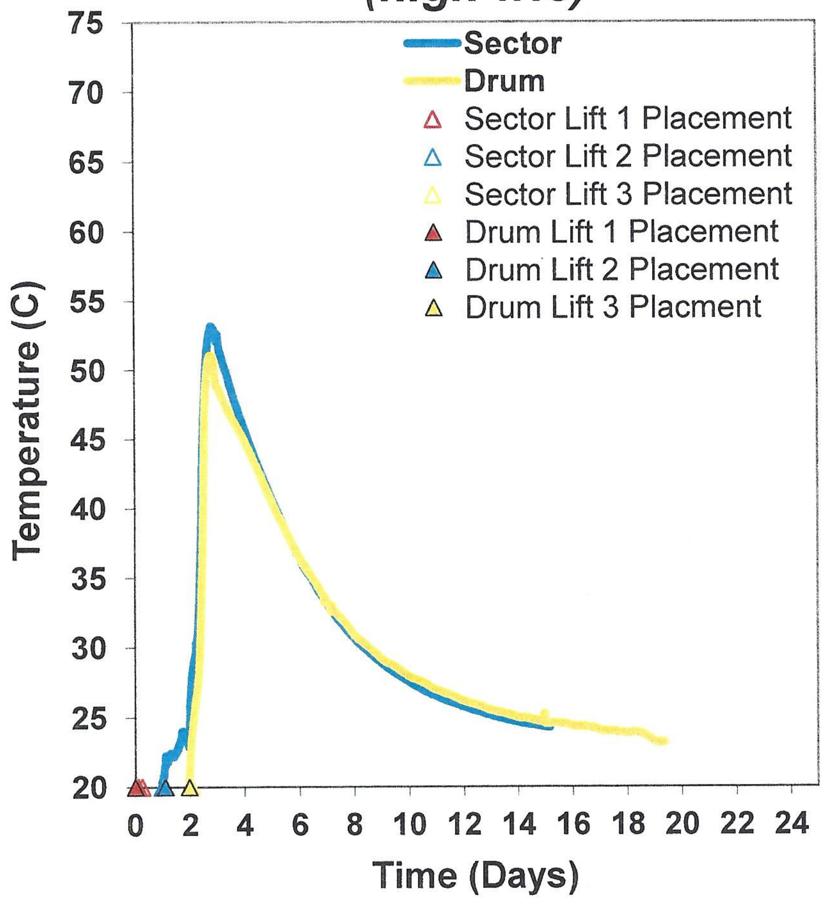
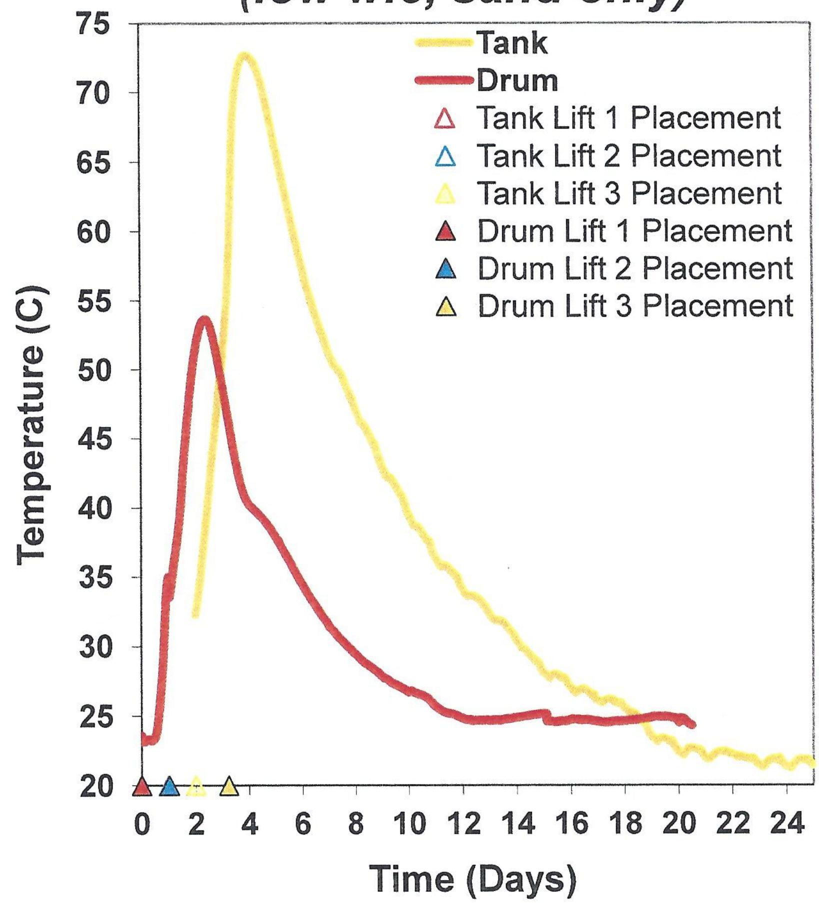
Peak Temperatures Scale with Specimen Size

SRS-like Strong Grout
(high w:c)



Alternative 1 Reducing Grout
(low w:c, sand only)



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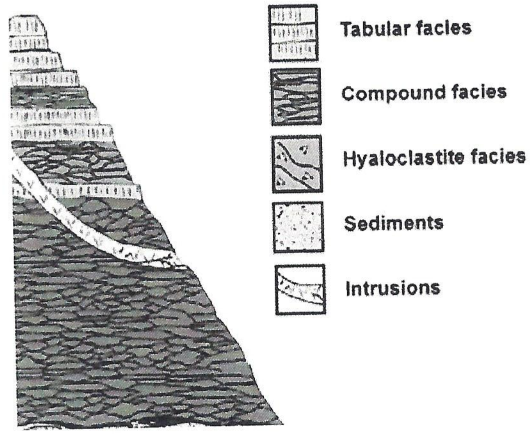
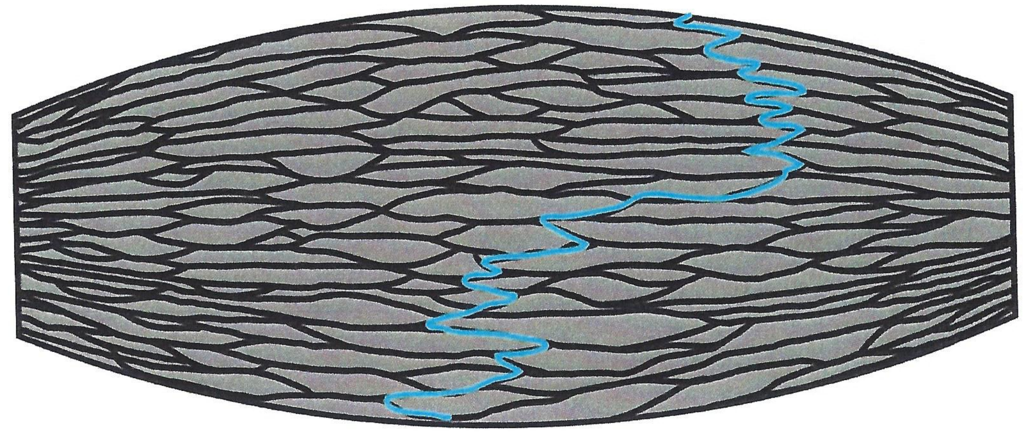
Grout Facies Architecture & Heterogeneity: Insights From Compound-Braided Basaltic Flows



Jerram et al. *Geol. Mag.* 2009

Likewise, grout monoliths of non-self-leveling grout are laterally/vertically heterogeneous, consisting of thousands of grout flow lobes prone to localized shrinkage and fast flow at their seams

The rheology of pahoehoe basaltic lava is somewhat similar to ropy grout; its facies architecture consists of thin, interfingering, compound-braided lava flow sheets and channels sourced by an episodic supply of magma.



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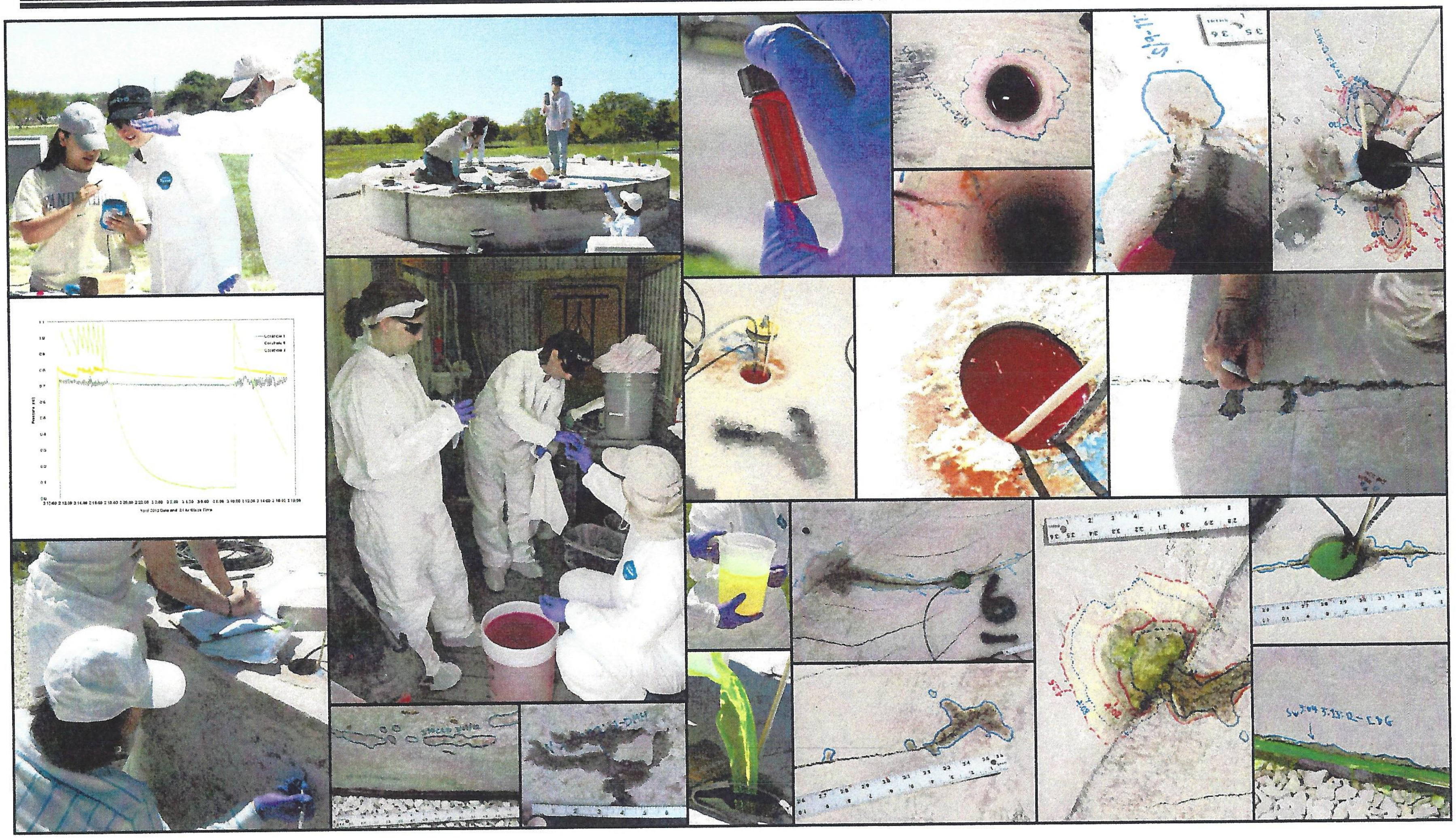
Slug Tests: 7 Orders of Magnitude *k* Variation & Numerous Fast Flow Pathways



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Faults May Develop from Differential Loading of Non-Self-Leveling Grout

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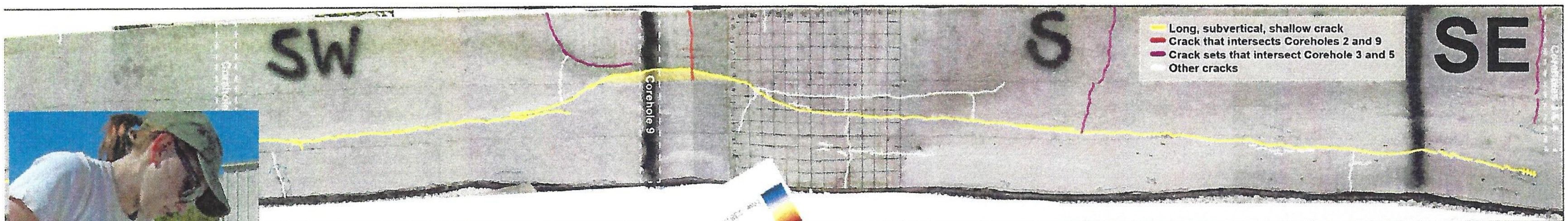

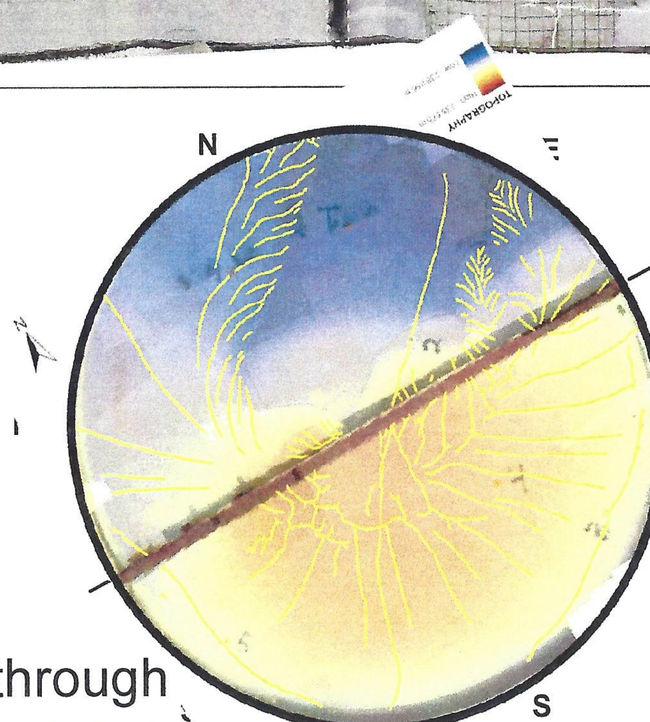

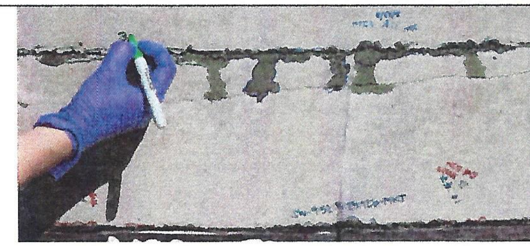

Permeable cracks or faults ($K \sim 10^{-2}$ cm/s; $k \sim 10^{-11}$ m^2) developed late through coreholes on the S/SW side of the monolith

A larger load was applied to the monolith on the southern side; faults may have accommodated movement of mounded grout to the low side of the monolith

Fast Flow Pathways & Performance Impact

- Staff identified these likely fast flow paths through grout monoliths:
  - Annular shrinkage gaps along tank steel liners, embedded pipes, cooling coils, and equipment
  - Shrinkage gaps at grout flow lobe seams and grout lift interfaces
  - Plastic differential settlement cracks that form above embedded items
  - Plastic shrinkage cracks (early) + drying shrinkage cracks (later)
  - Faults formed as a result of differential loading of non-self-leveling grout
- If infiltrating groundwater is unable to react significantly with reducing grout due to rapid bypass flow through cracks and shrinkage gaps, the relatively low solubility of key radionuclides that was assumed in DOE's PA may not be achieved and risk-significant releases may occur earlier than assumed

Conclusions

- Staff interpretations of grout flow behavior during placement, grout facies architecture, and data that describe the evolution of shrinkage gaps and hydrologic properties provide risk insights and identify uncertainties about grout performance
- Project results help NRC and CNWRA staff evaluate credit taken for similar engineered waste containment systems, such as those located at INL INTEC Tank Farm Facility (Idaho) and at the SRS F- and H-Tank Farms (South Carolina)