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Sandia National Laboratories

FCT UFD Crushed Salt Mechanical Testing Results to Date

Frank Hansen

Scott Broome

Steve Bauer

Alex Urquhart

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PTKA Project Management Agency Karlsruhe within Karlsruhe Institute of Technology

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Motivation for Studies

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- Reconsolidation of crushed salt is an important physical phenomenon when backfilling or sealing nuclear waste repositories in salt.
- There is a renewed national and international interest in salt reconsolidation at elevated temperature, particularly as applied to disposal of heat-generating nuclear waste.
- Most salt reconsolidation studies have been at room temperature, with a few tests at elevated temperatures up to 100°C.
- Test Plan presents an experimental procedure for a laboratory study of reconsolidation of crushed salt, emphasizing testing at elevated temperature.

Approach

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- Experiments designed to quantitatively evaluate consolidation as a f (σ. T).
- Determination of deformational processes by which the salt reconsolidates equally important.
- Laboratory studies intended to provide data representing consolidation behavior as a f (σ. T)up to 250˚C.
- The deformational processes are determined by optical and scanning electron microscopic examination of the deformed substructures.

Approach (Test Matrix)

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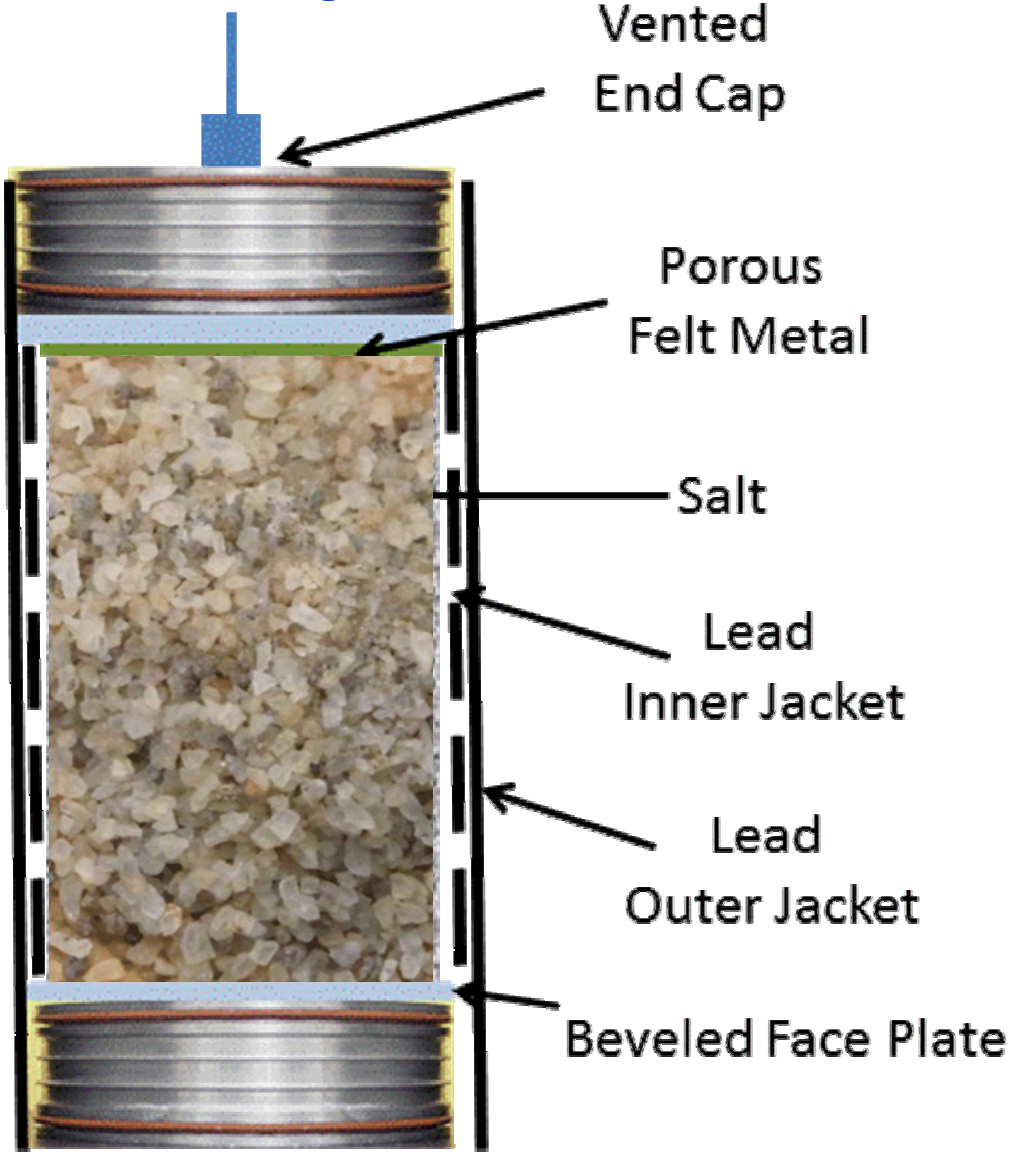
Test Number	Test Type	T (°C)	Maximum Confining Pressure (MPa)	Stress Difference (MPa)	Axial Stress (MPa)	Mean Stress (MPa)	Description
7	Isostatic	250	20.0	0.0	20.0	20.0	Quasistatic
8/9	Isostatic/Shear	250	10.0	10.0	20.0	13.33	Quasistatic
1/10-16	Isostatic/Shear	100	2.5	2.50/5.0	5.0/7.5	3.33/4.17	Quasistatic-Creep
2/11-17	Isostatic/Shear	100	5.0	2.50/5.0	7.5/10.0	5.83/6.67	Quasistatic-Creep
3/12-18	Isostatic/Shear	175	2.5	2.50/5.0	5.0/7.5	3.33/4.17	Quasistatic-Creep
4/13-19	Isostatic/Shear	175	5.0	2.50/5.0	7.5/10.0	5.83/6.67	Quasistatic-Creep
5/14-20	Isostatic/Shear	250	2.5	2.50/5.0	5.0/7.5	3.33/4.17	Quasistatic-Creep
6/15-21	Isostatic/Shear	250	5.0	2.50/5.0	7.5/10.0	5.83/6.67	Quasistatic-Creep

Sample Assembly



Experimental Setup

Pretest

Post test

Experimental Setup

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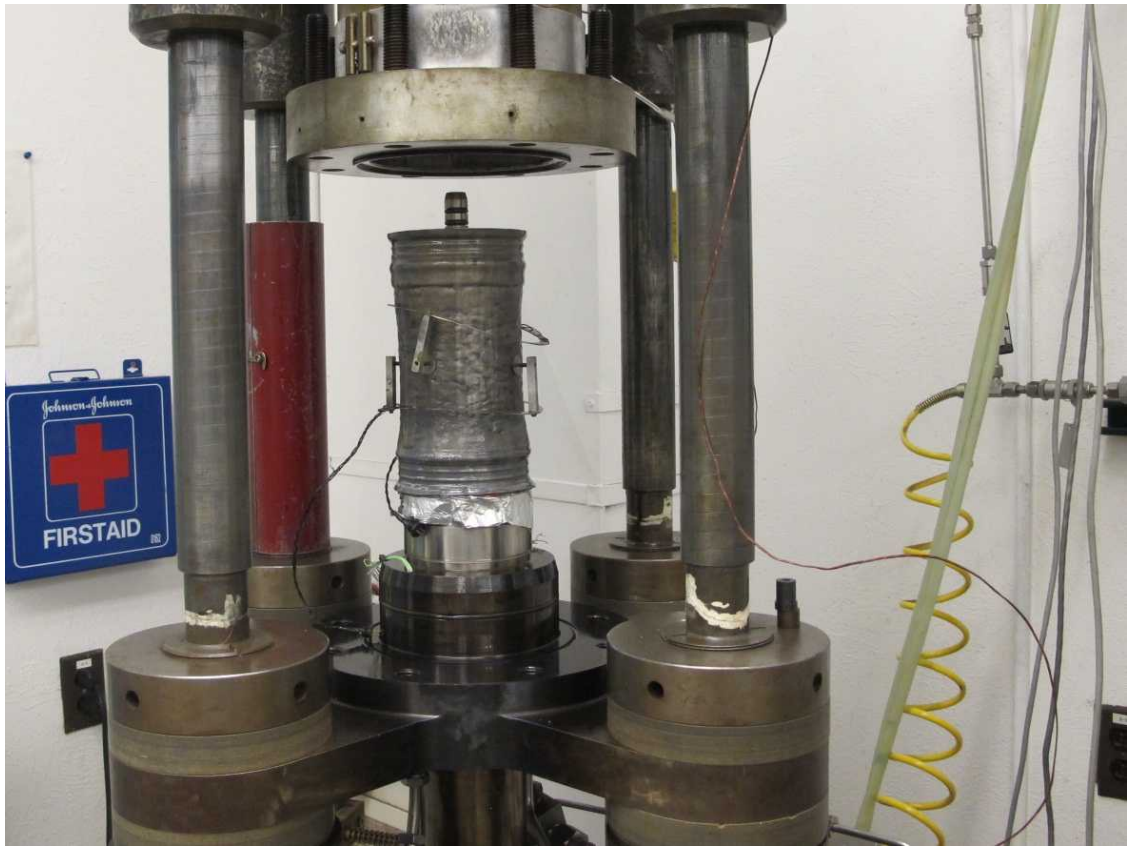

Challenges and Observations

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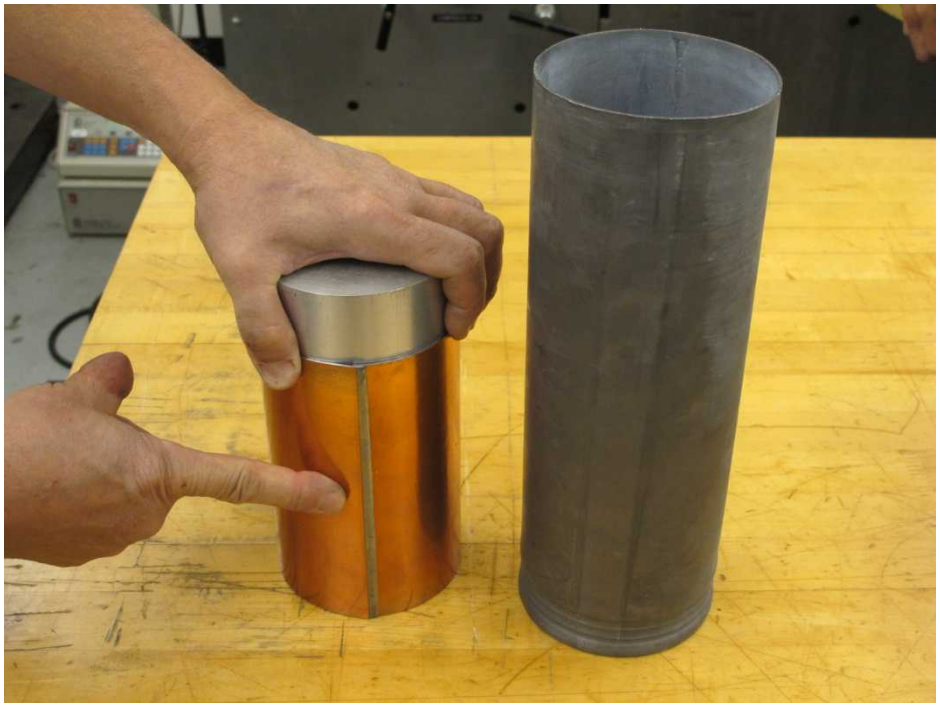
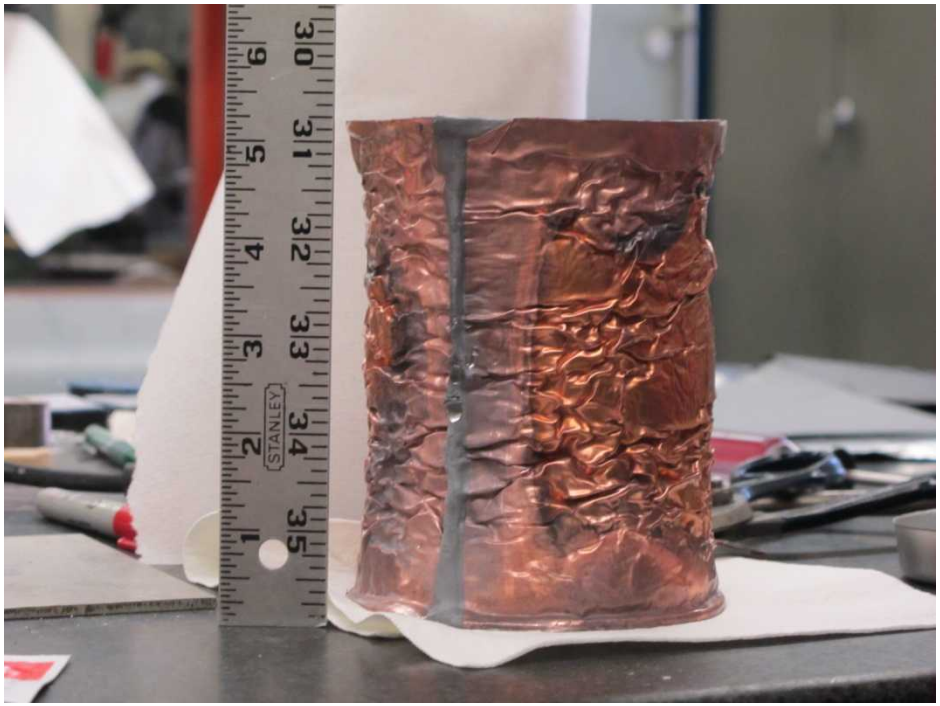
- Jacket leaks were problematic at 250˚C
- Intermediate thin copper shim (0.005”) used as a soft barrier between lead jackets





Challenges and Observations

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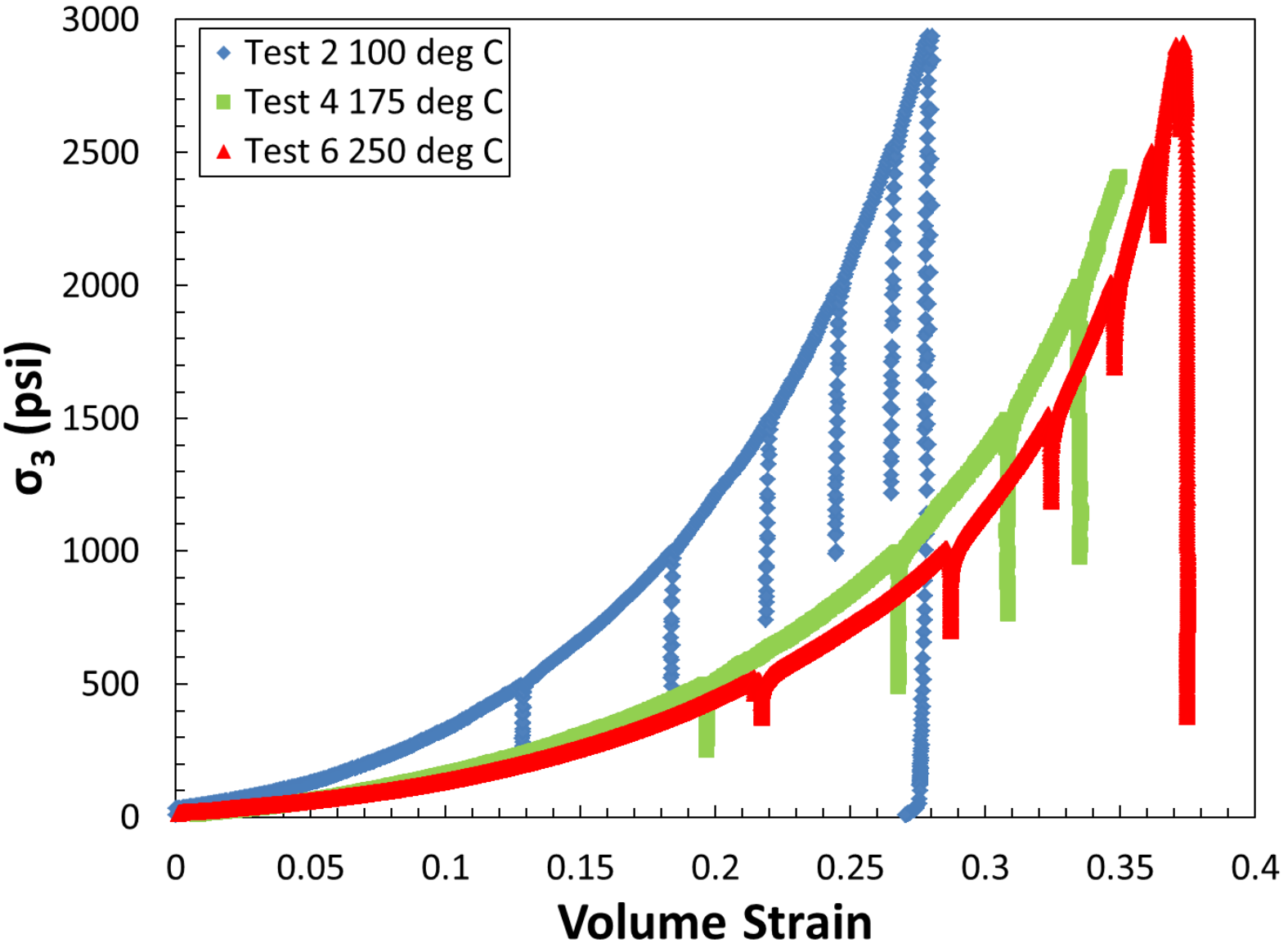
- Water was observed existing sample vent hole on 250˚C tests during heating
- This observation begs the question of the potential for a dry environment for high level waste disposal in (this) bedded salt

Summary of Tests Completed to Date

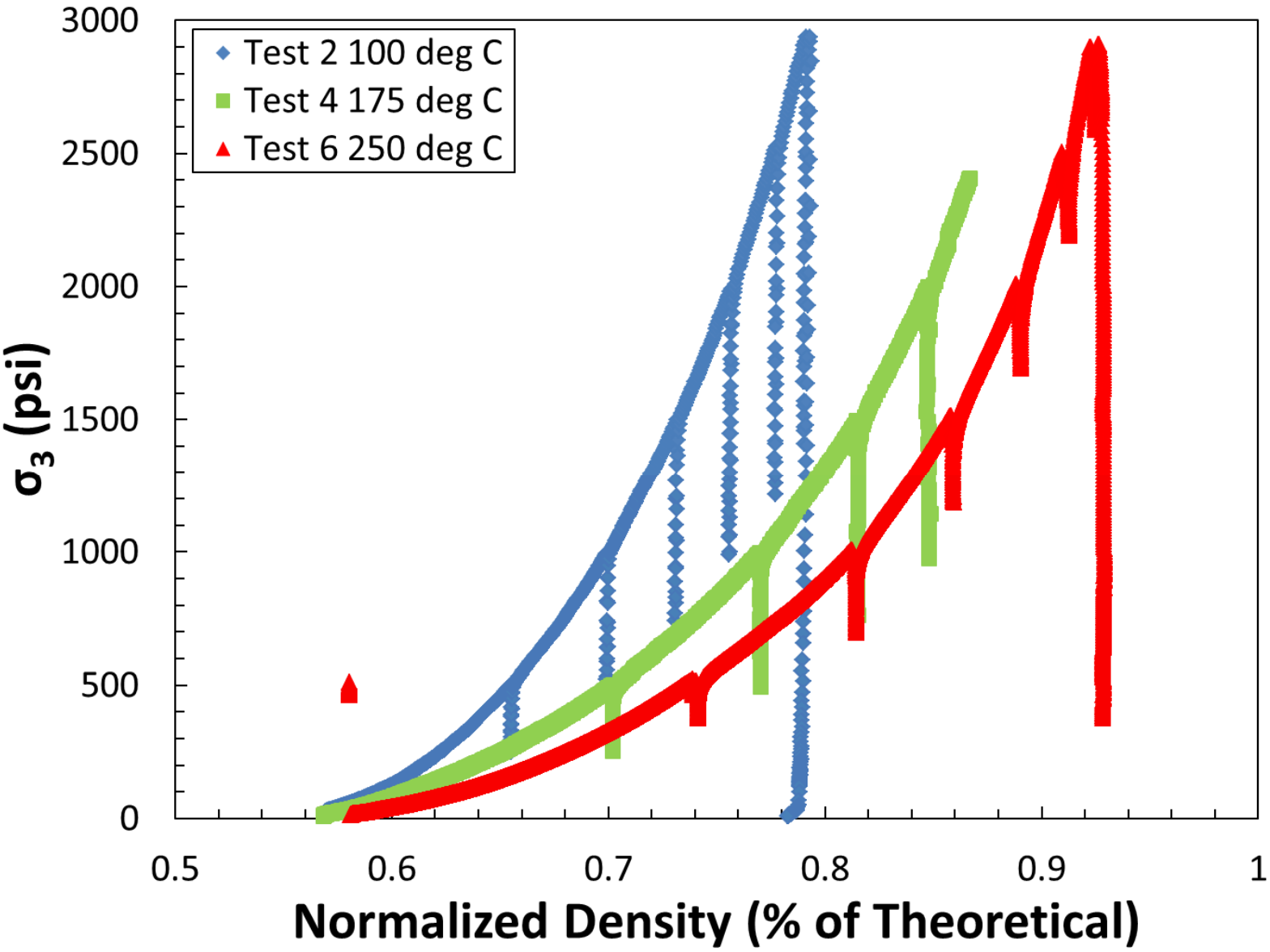
Test number (Scientific Notebook number sequence)	Date of test	Sample ID	Total ε_V (%)	Normalized Density (% of theoretical)	Confining pressure obtained (psi)	Tests satisfied from test matrix
2	6/28/2011	FCT-CS-HQ-100-02	28	79	2900	1,2
3	7/6/2011	FCT-CS-HQ-250-01	29, Leak	78, Leak	800	5,6
4	7/12/2011	FCT-CS-HQ-175-01	35	87	2400	3,4
5	1/19/2012	FCT-CS-HQ-175-02	N/A piston contacted sample early			None
6	3/15/2012	FCT-CS-HQ-250-02	37	93	2900	5,6,7,8
7	4/4/2012	FCT-CS-SQ-250-01	31,σ_C*	84,σ_C*	1450	8
8	5/1/2012	FCT-CS-SQ-250-02	37	93	1450	9
9	5/8/2012	FCT-CS-CR-250-01	33	86	363	14,20
10	5/23/2012	FCT-CS-CR-250-02				None (leak)
11	6/19/2012	FCT-CS-CR-250-03				None (leak)
12	6/27/2012	FCT-CS-CR-250-04				None (leak)
13	7/3/2012	FCT-CS-CR-175-01	31	86	363	12,18
14	7/11/2012	FCT-CS-CR-175-02	32	85	725	13,19
15	7/23/2012	FCT-CS-CR-100-01	19	73	363	10,16 second stage creep not run
16	7/24/2012	FCT-CS-CR-250-05	40	94	725	15,21
17	7/27/2012	FCT-CS-CR-100-02	26	77	363	10,16
18	8/9/2012	FCT-CS-CR-100-03	33	86	725	11,17

*Values obtained after hydrostatic compaction and are not available after the shear stage.

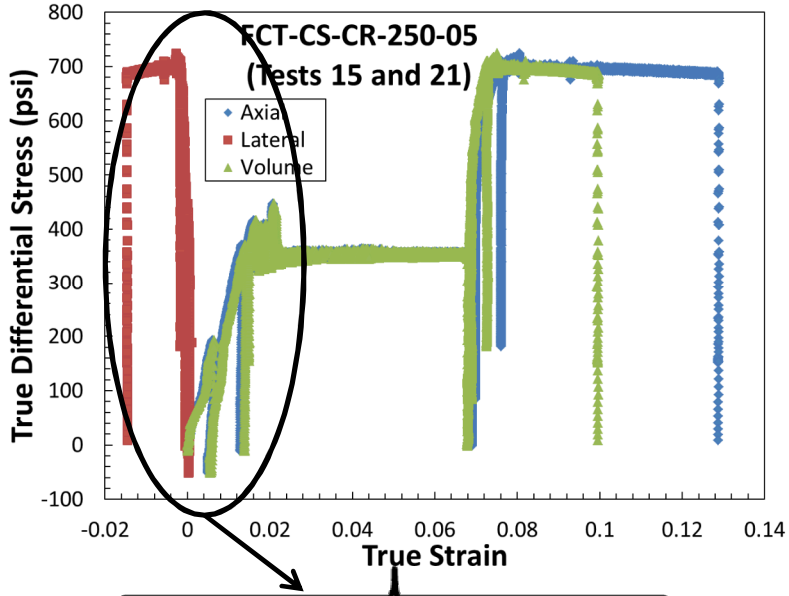
Pressure versus Volume Strain

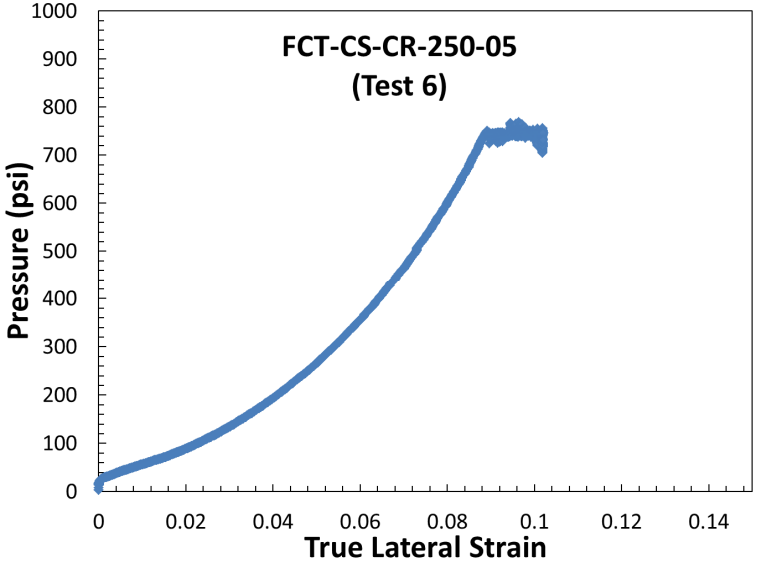


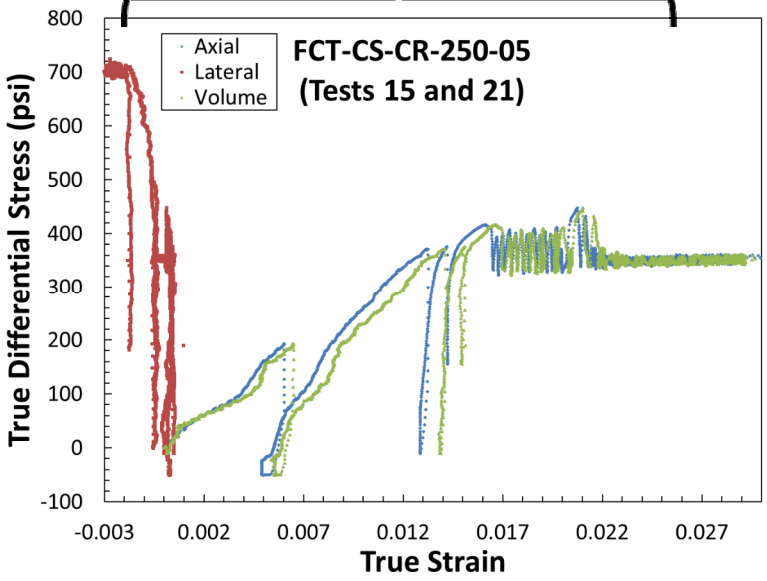
Pressure versus Fractional Density

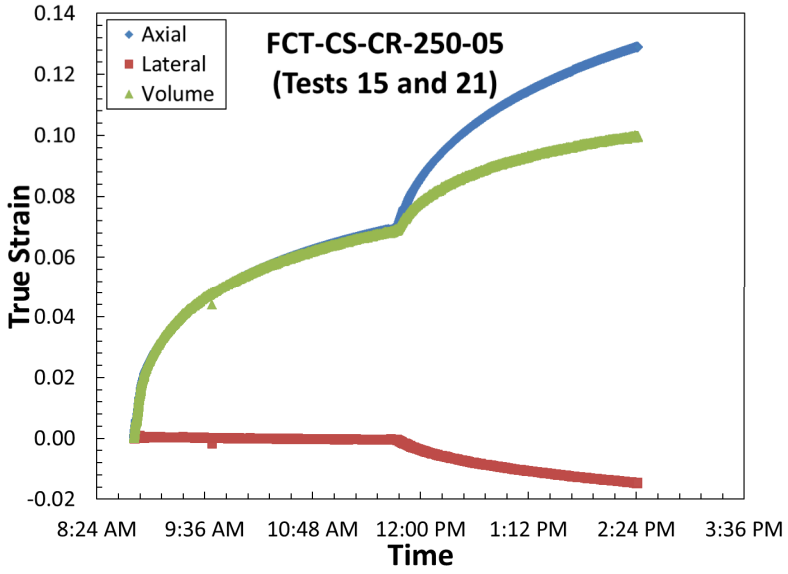


250˚C Staged Test Results

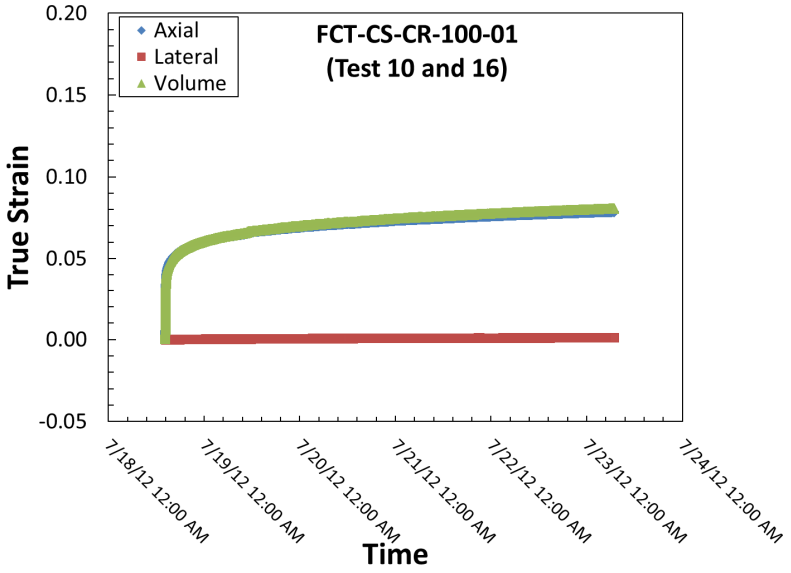


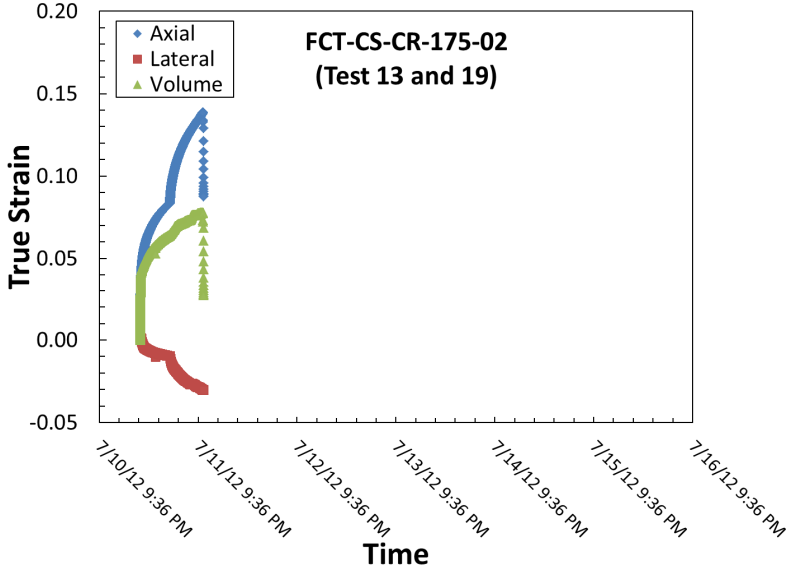


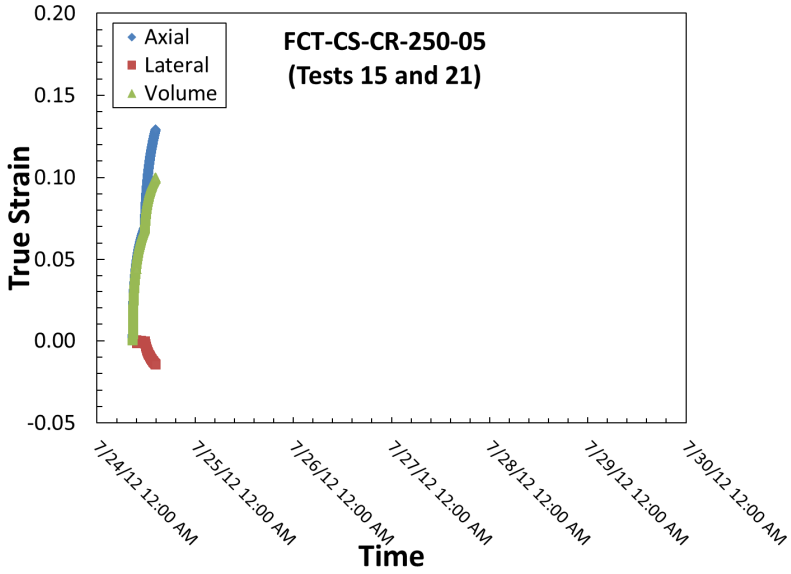


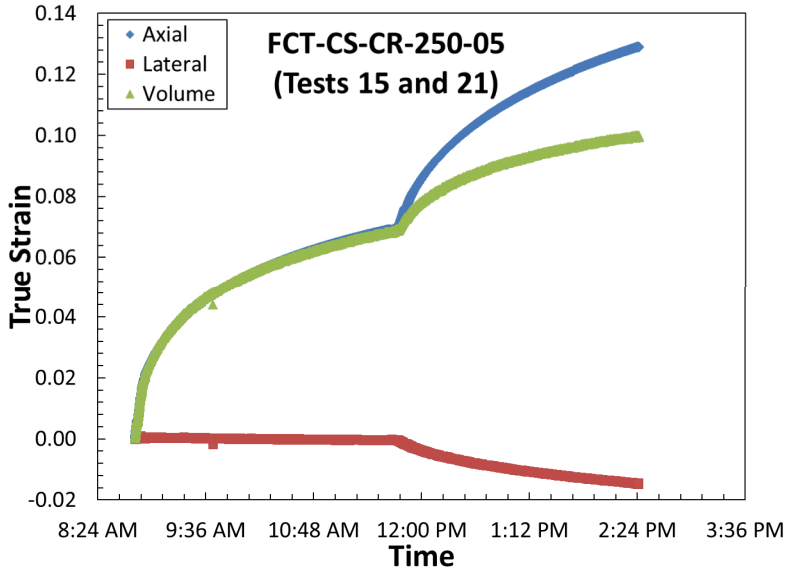


ε_V versus time; staged tests









Microprocesses of Reconsolidation

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- Samples cut in half, then quartered with a low damage wire saw
- “Thick” optical slides were made for most material
- Freshly broken faces were coated and examined in the SEM
- Individual crystals were cleaved and etched in some cases

100°C 250°C

Conclusions

- Hydrostatic tests
- Pressure versus εV
- Pressure versus Fractional Density
- Multistage hydrostatic and shear (quasistatic and creep) tests completed
- Differential stress versus strain

- Final εV and fractional density linked to post test microscopy
- Data will be fit to the Callahan model

- Experimental work is ongoing