SAND2014-4315C

Experimental Determinations of Thermophysical Properties of Reconsolidated Crushed Salt

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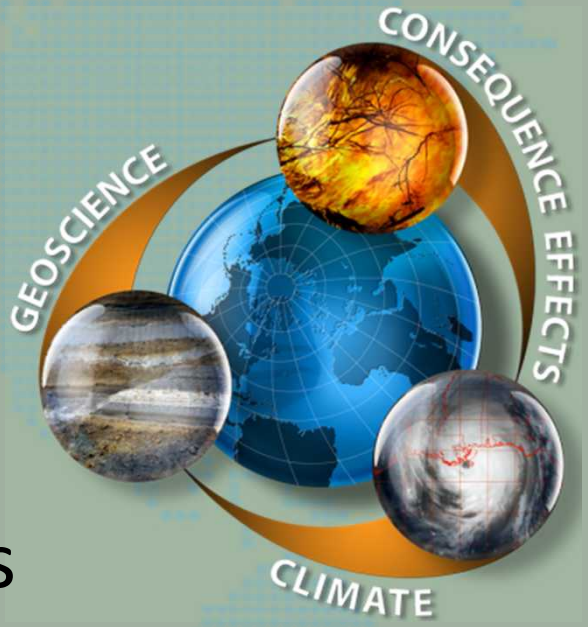

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Outline

- **Definitions**
- **Process**
- **Motivation**
- **Results**
- **Methods**
- **Results**
- **Conclusions**

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Thermal Conductivity

- Thermal conductivity (**K**)is the property of a material to conduct heat
- Heat transfer occurs at a higher rate across materials of high thermal conductivity than across materials of low **K**.
- TC of rock salt > that of other sedimentary rocks.
- Thermal gradients in salt bodies may be lower than in surrounding sediments

K is expressed as Watts per meter Kelvin

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Process

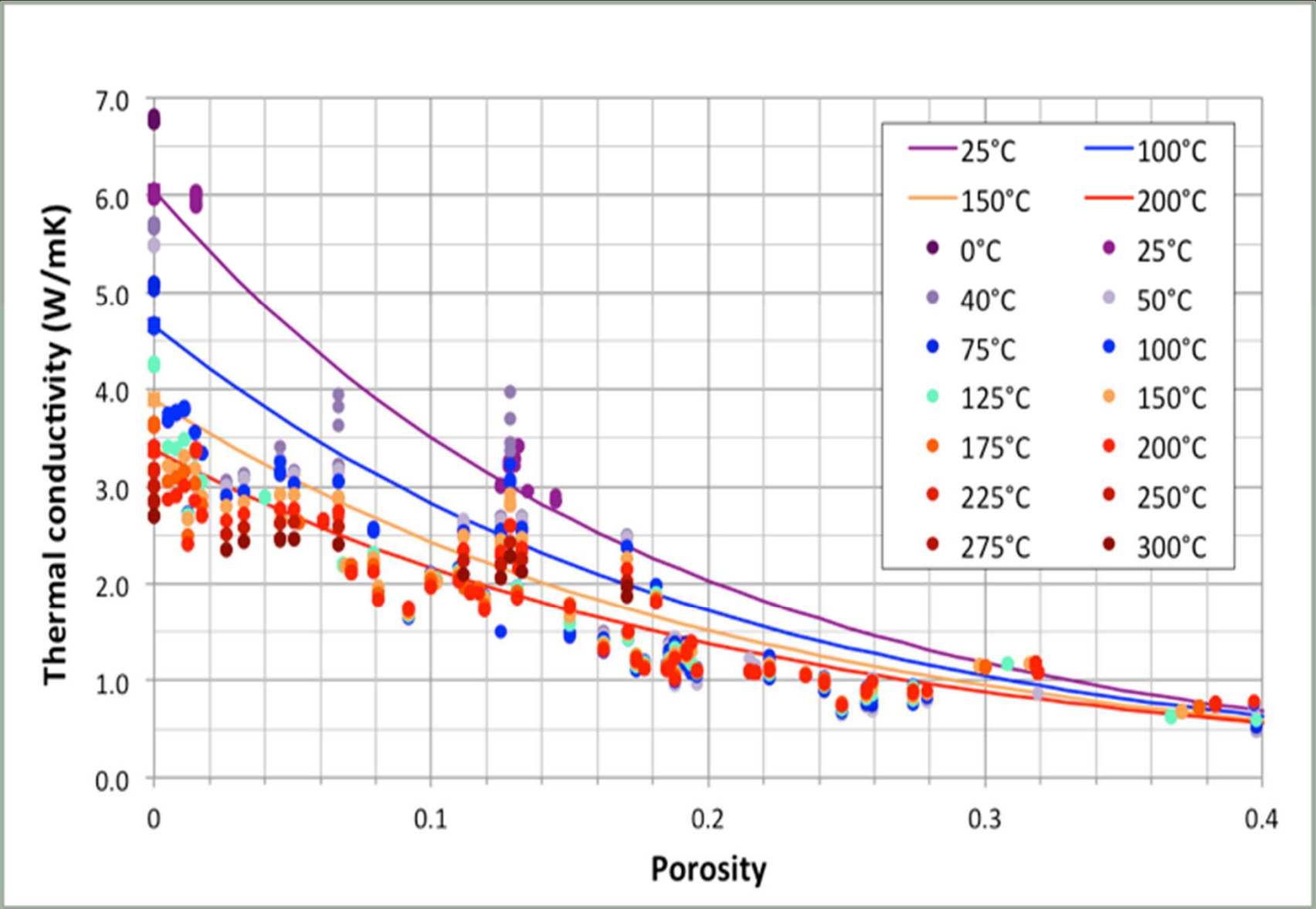
- Started with crushed salt
- Compacted it to a range of densities
- Measured thermal properties (here **K**) of compacted salt
- Measured thermal properties single crystal salt
- Measured thermal properties fractured salt
- Intent on understanding measured values, model

Motivation

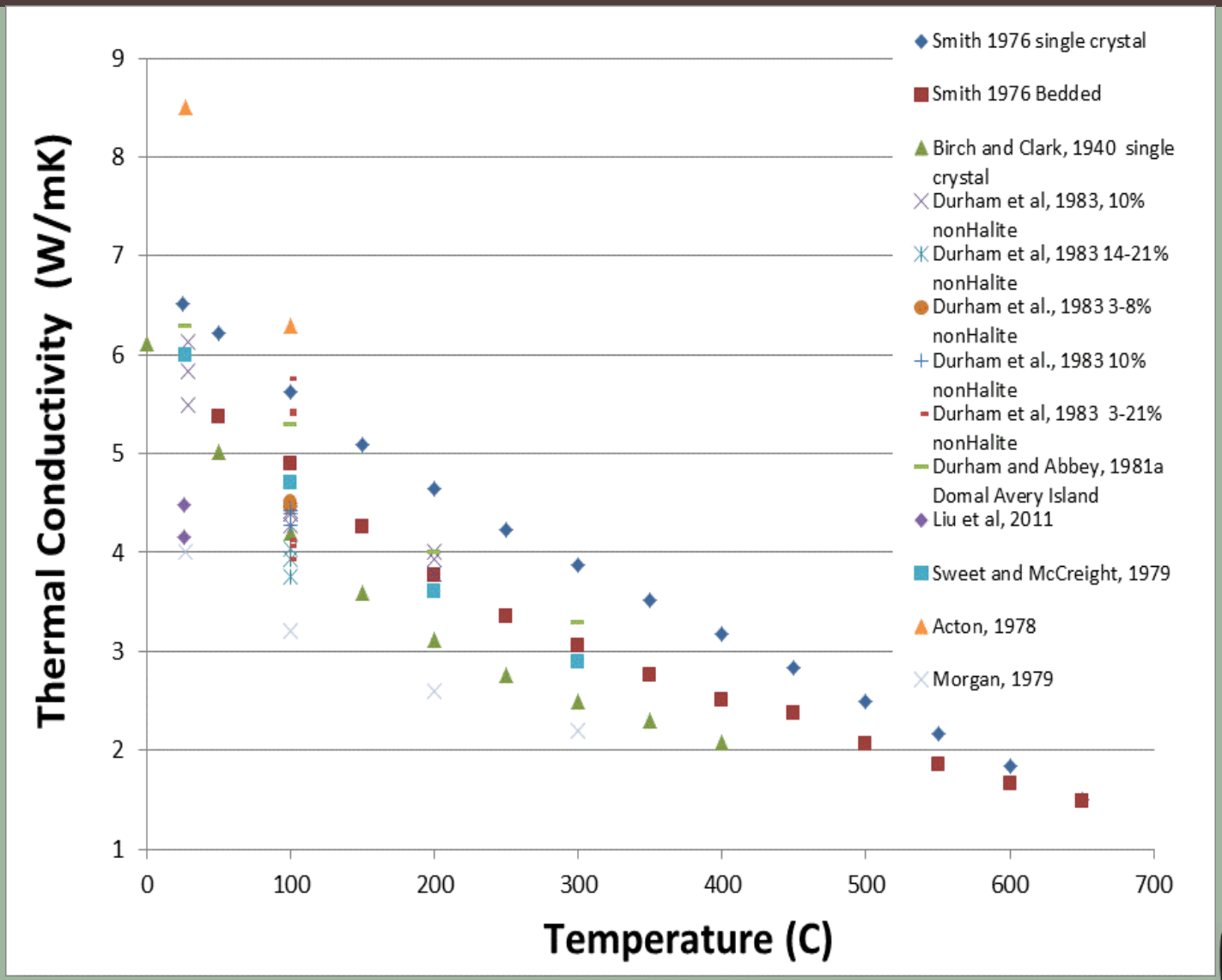
High Level Nuclear Waste Disposal

Re-consolidation of crushed salt is an important element of disposal concepts, thermal mechanical modeling is fundamental to design, analysis and performance assessment

Results


Thermal conductivity (W/mK)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
0.1
0.2
0.3
0.4
Porosity
25°C
100°C
150°C
200°C
0°C
25°C
40°C
50°C
75°C
100°C
125°C
150°C
175°C
200°C
225°C
250°C
275°C
300°C

Selected thermal conductivity data from previous workers



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Salt materials studied

“crushed salt”

compacted crushed salt

domal salt

single crystal

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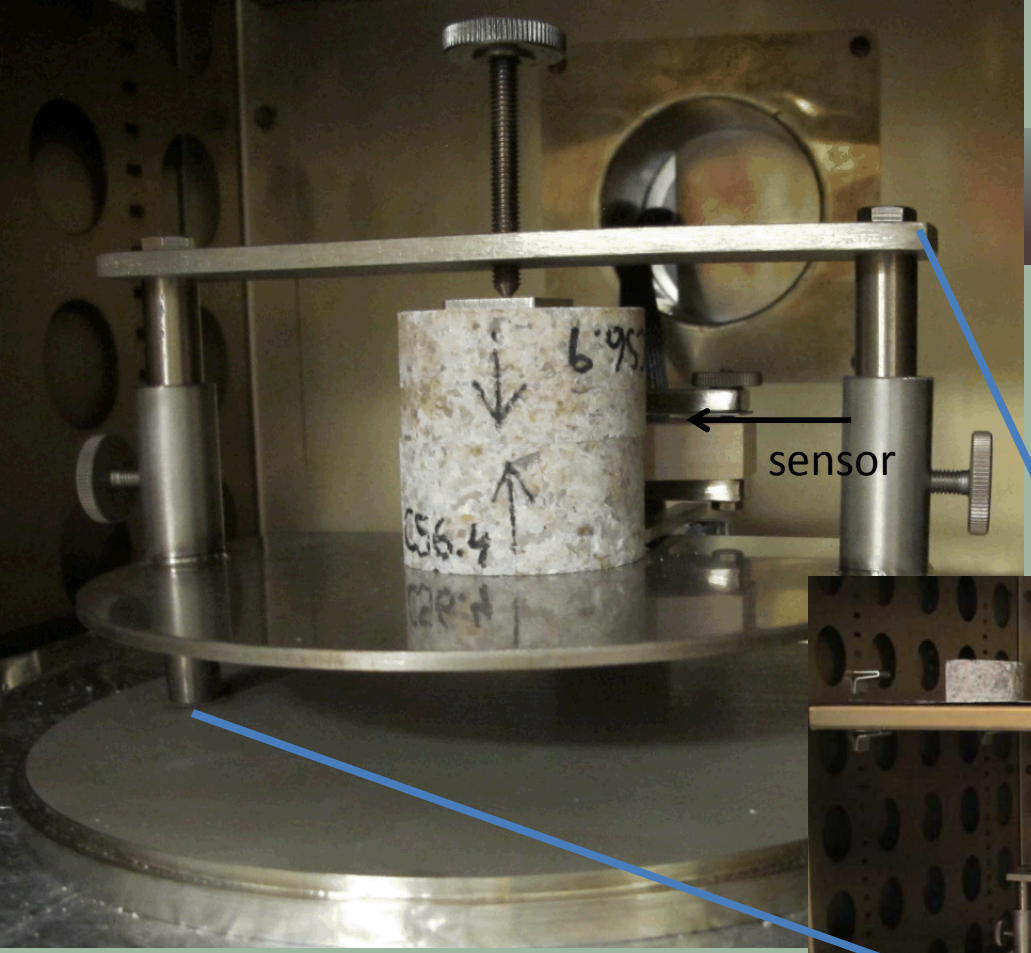

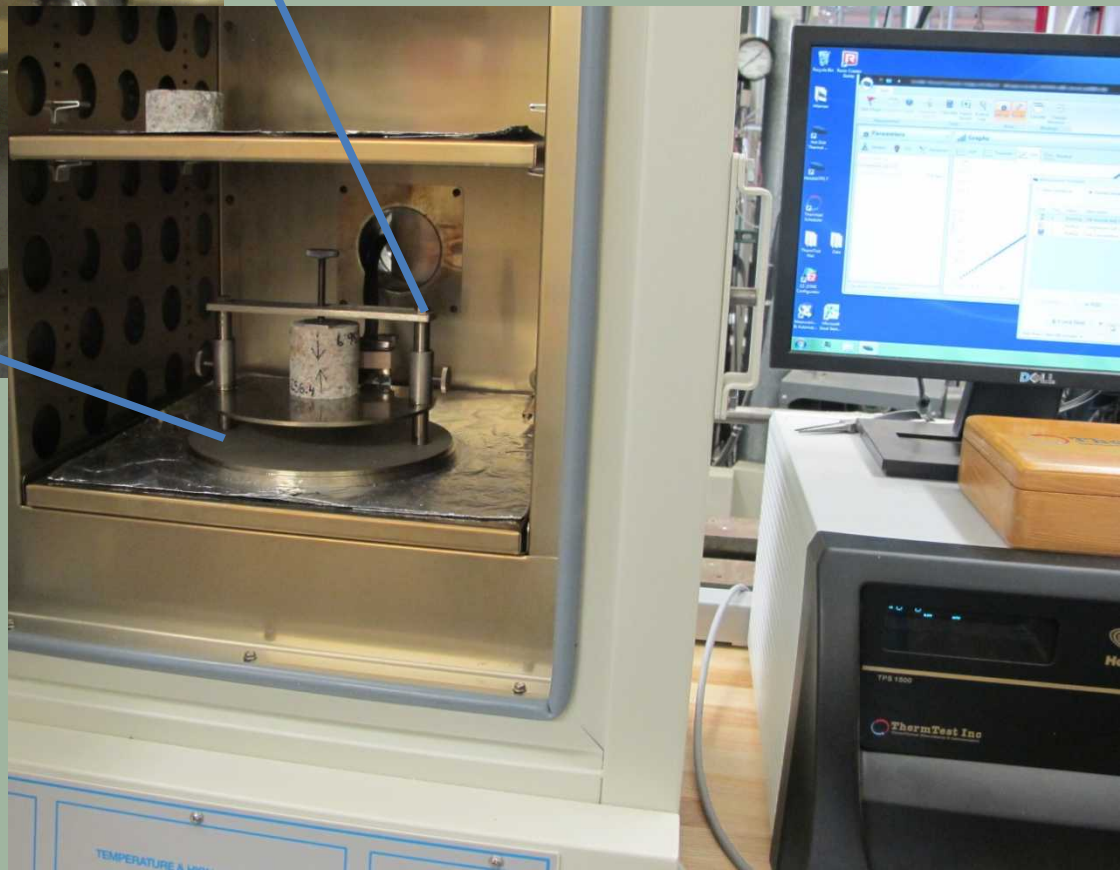

Thermal conductivity device

Single Crystal Sample

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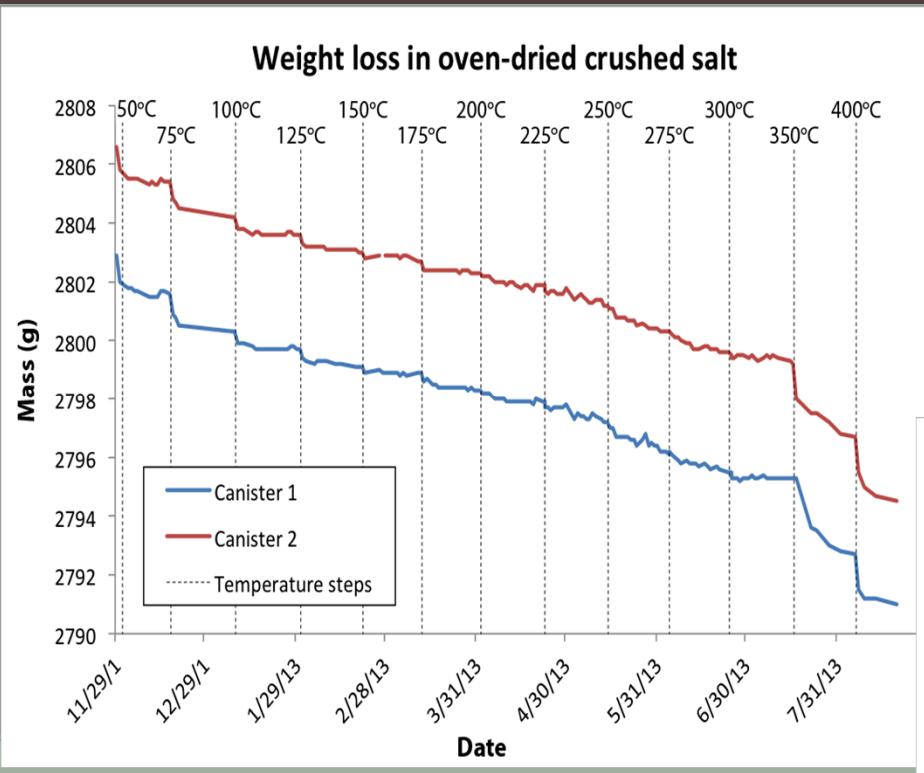
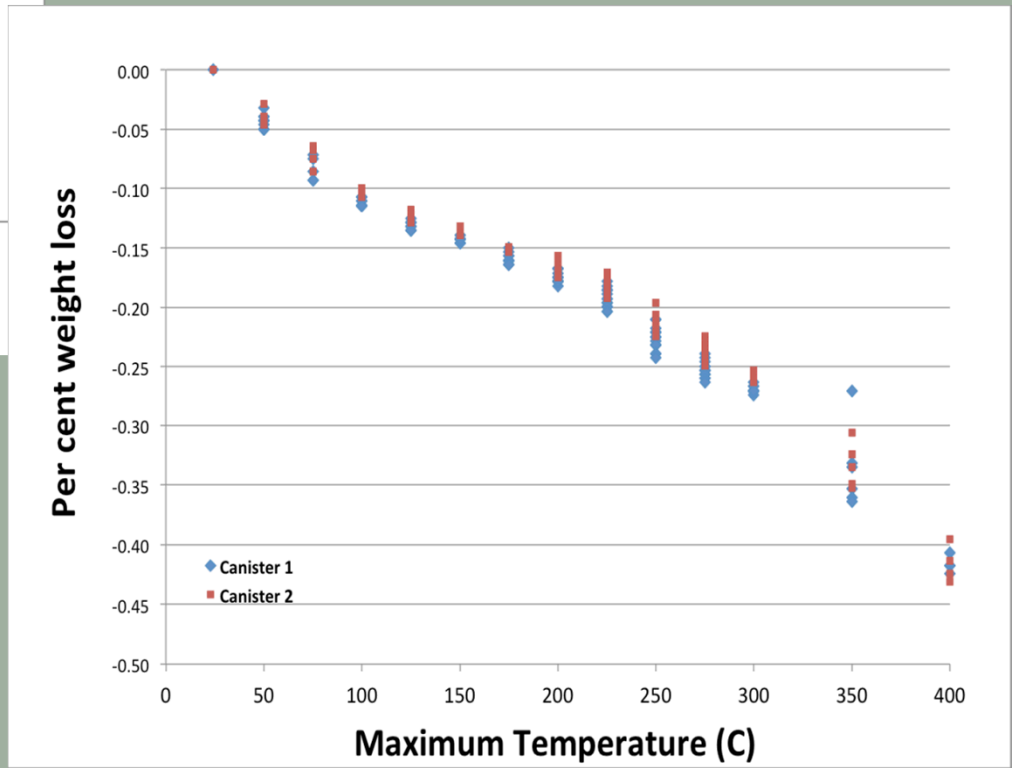
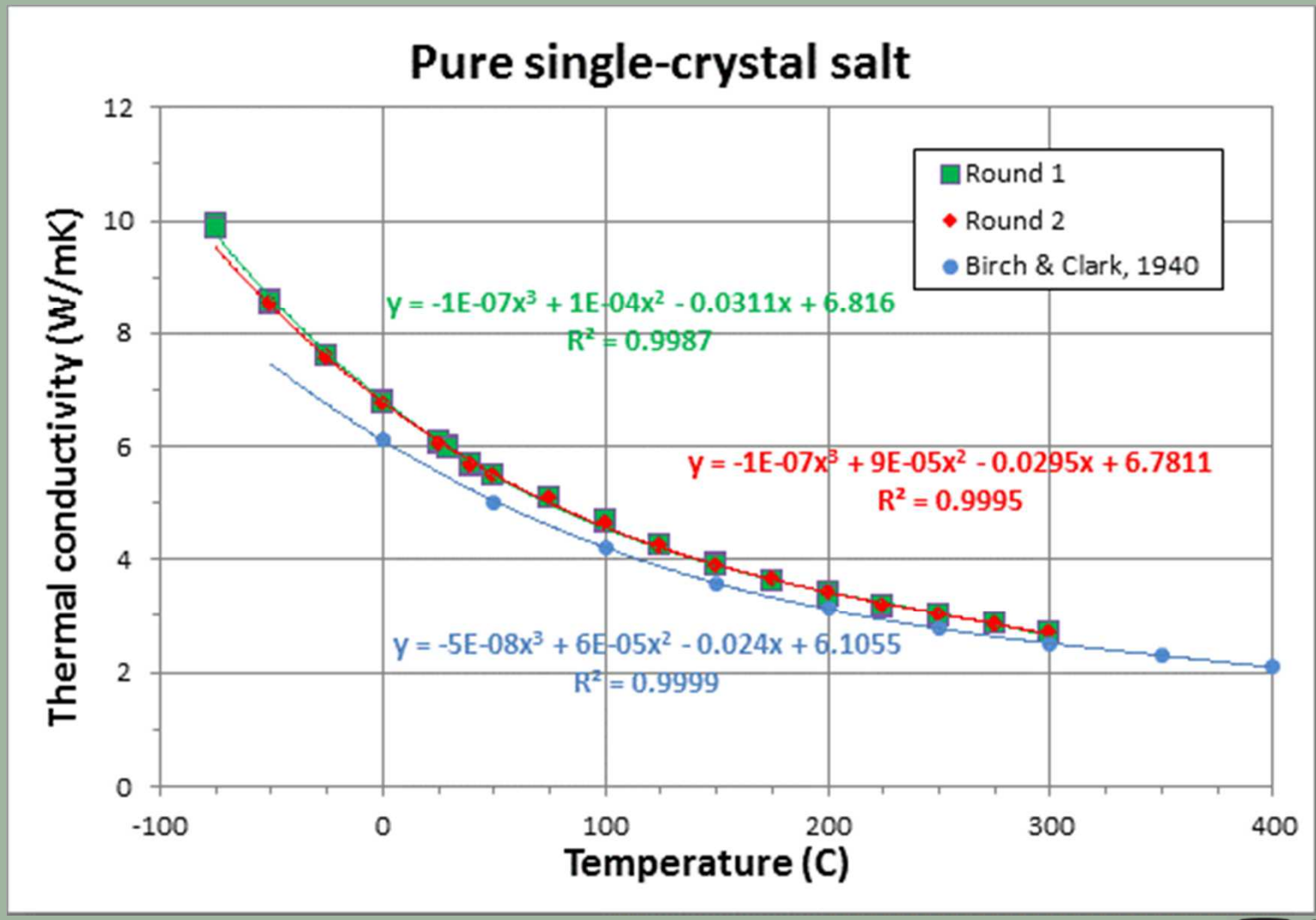
Salt Drying Measurements





Thermal conductivity of single-crystal halite



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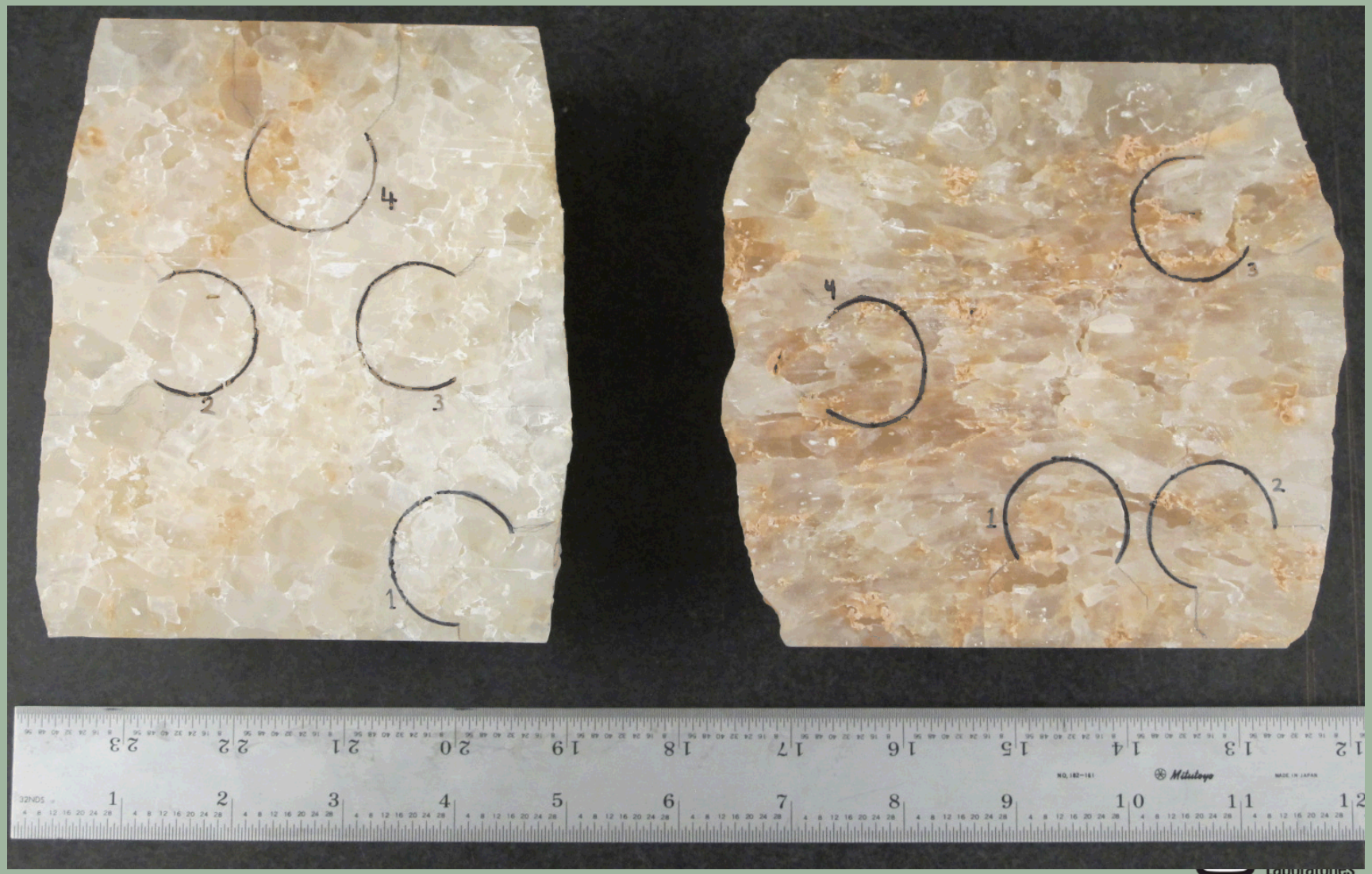
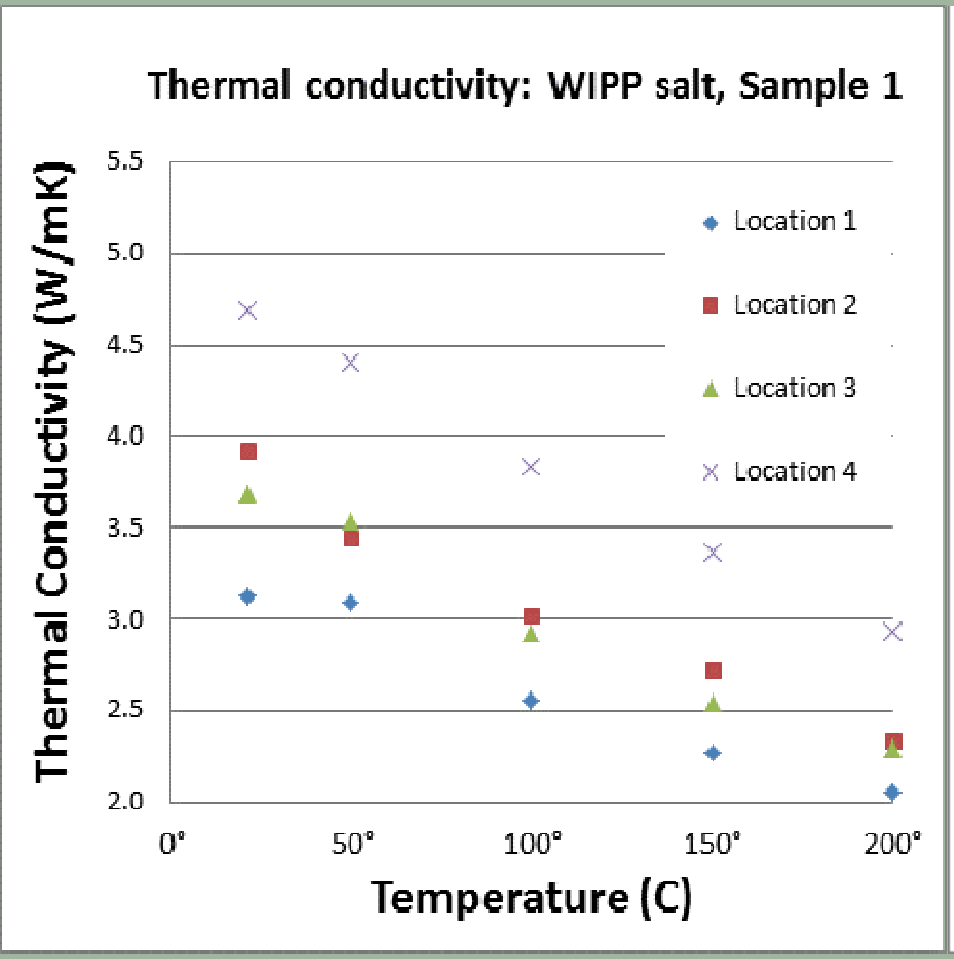
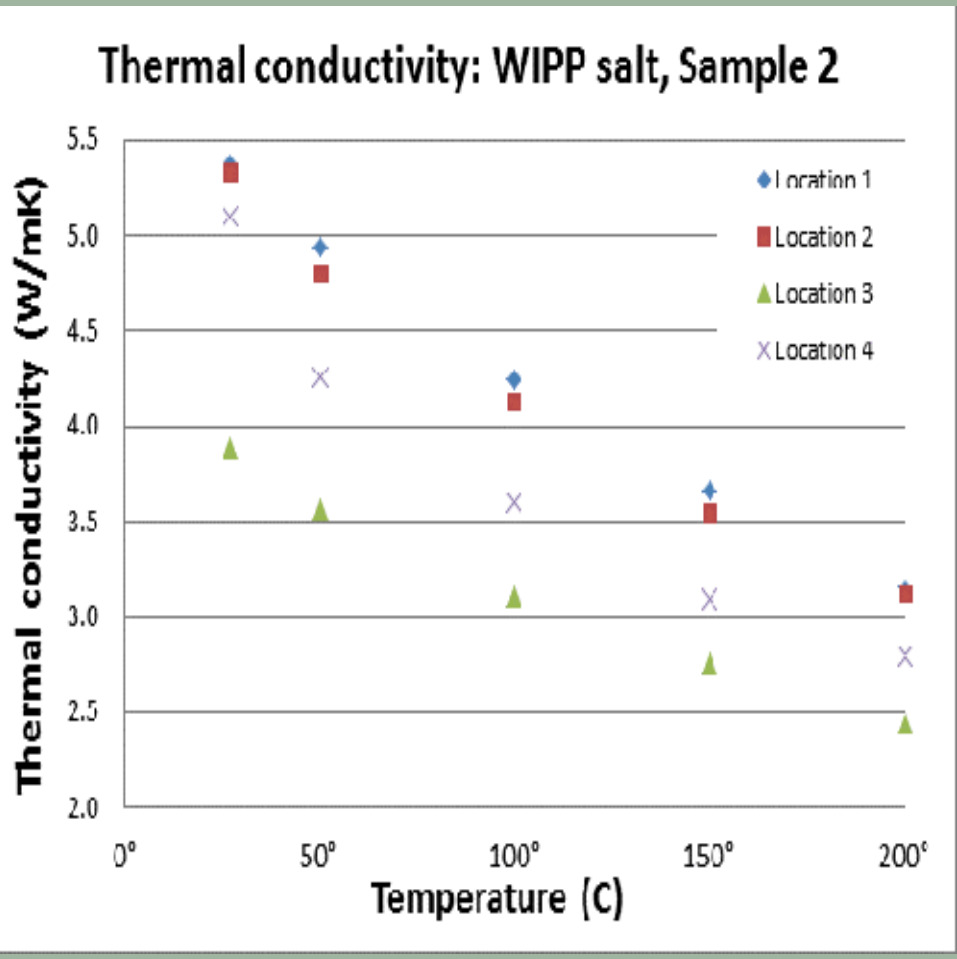
Fractured bedded salt samples 1, 2 with locations of thermal conductivity measurements



Thermal conductivity of fractured salt





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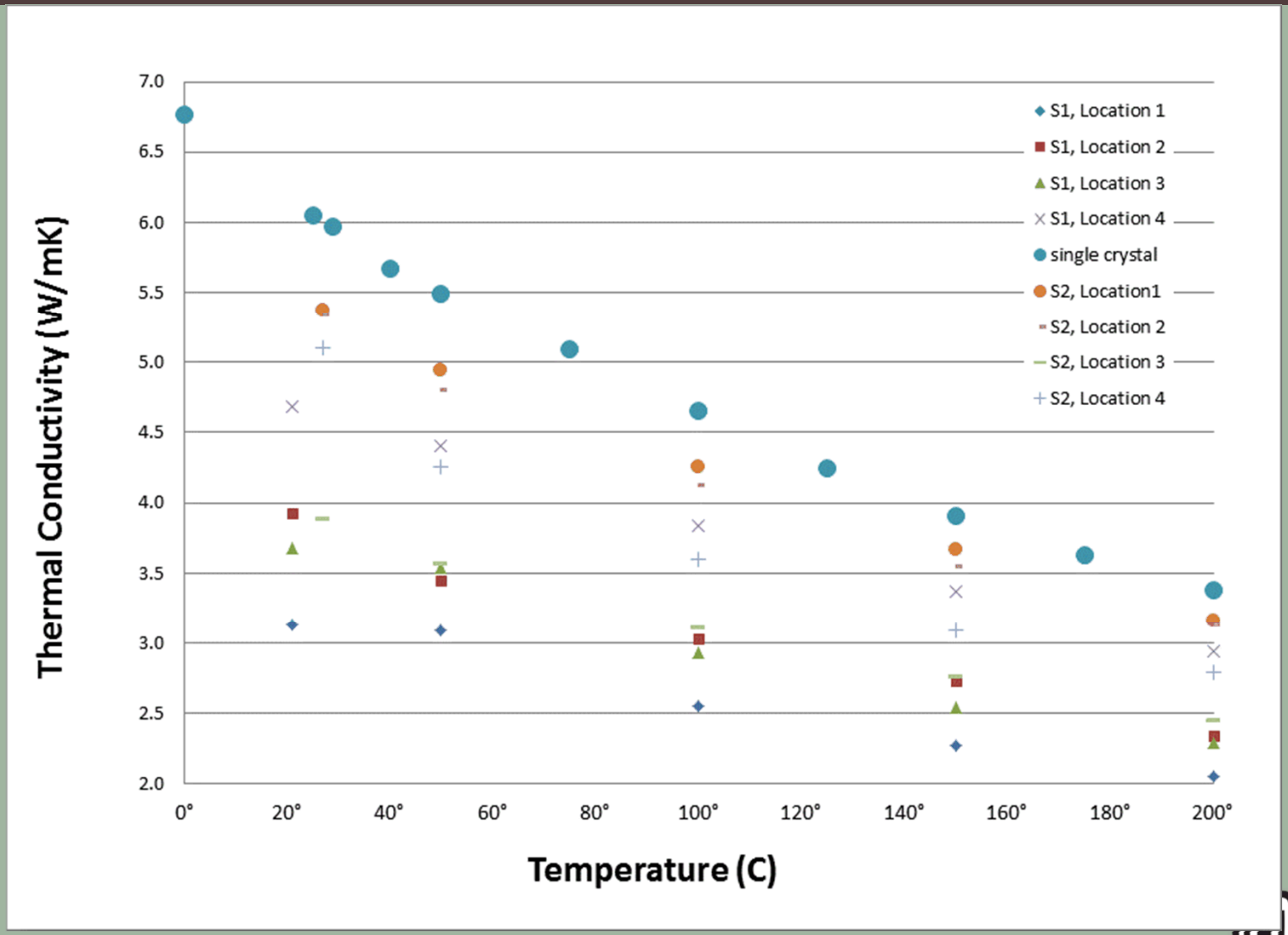
Comparison of single crystal and fractured salt thermal conductivity.



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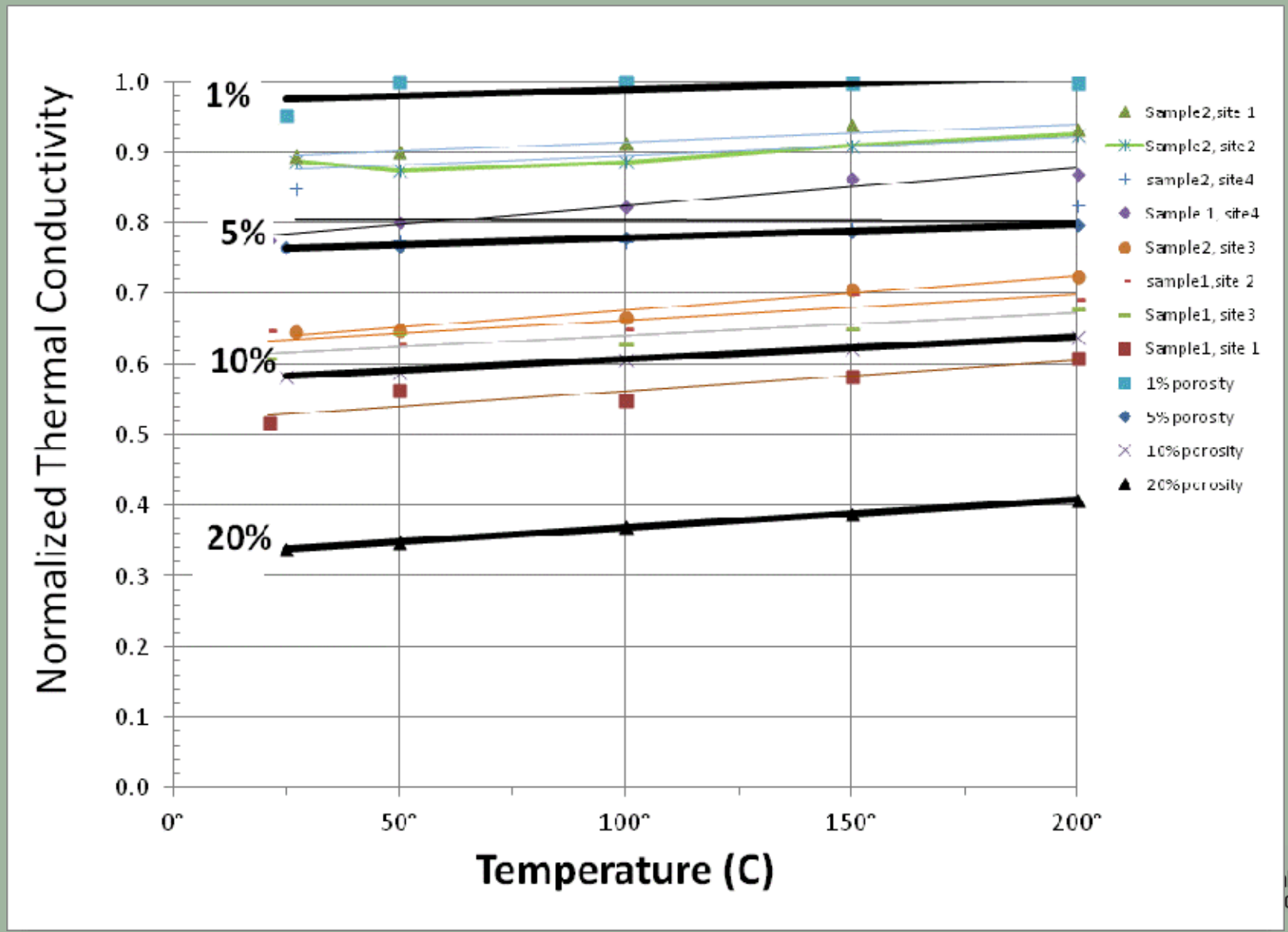
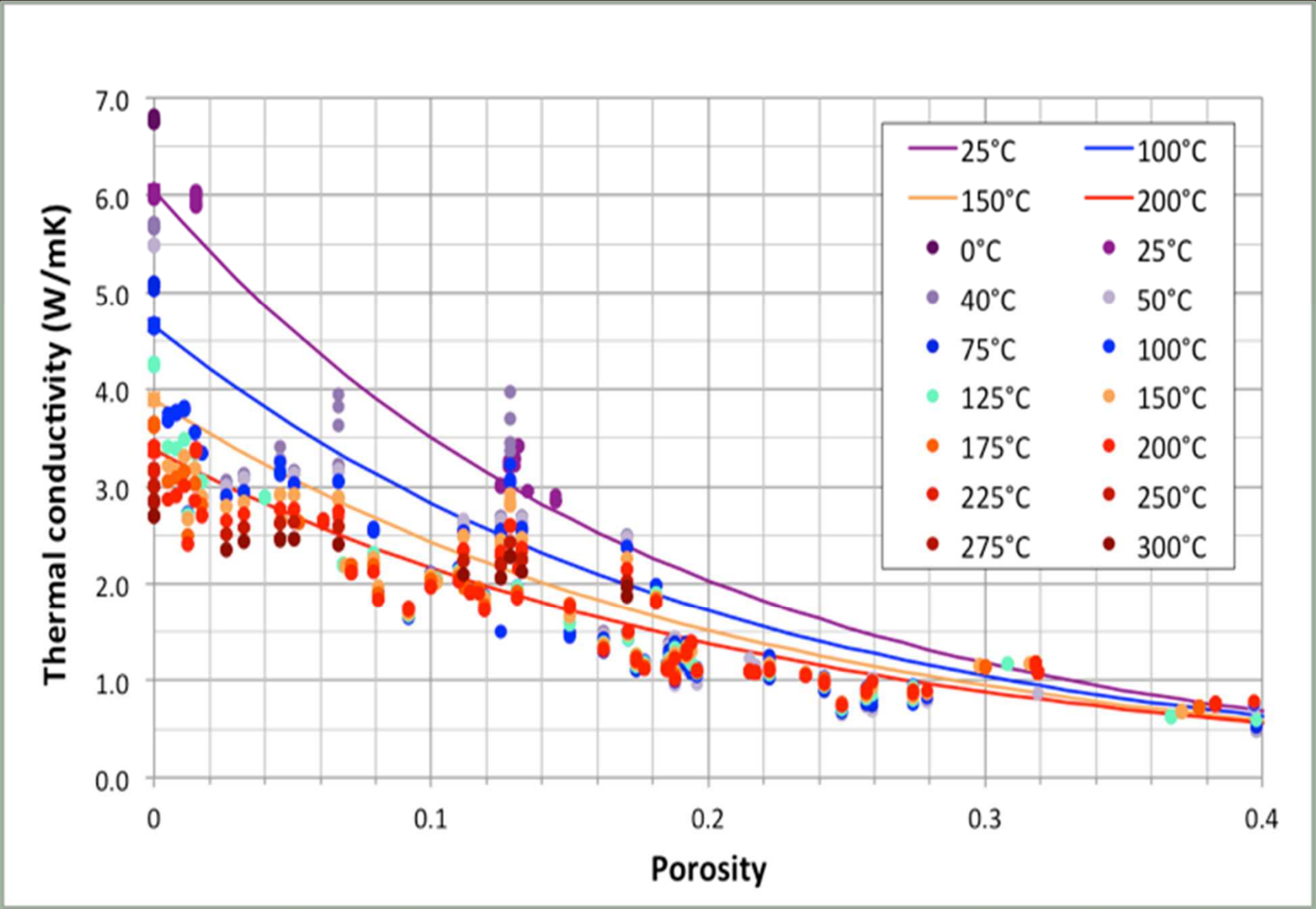
Normalized TC vs Temperature



Results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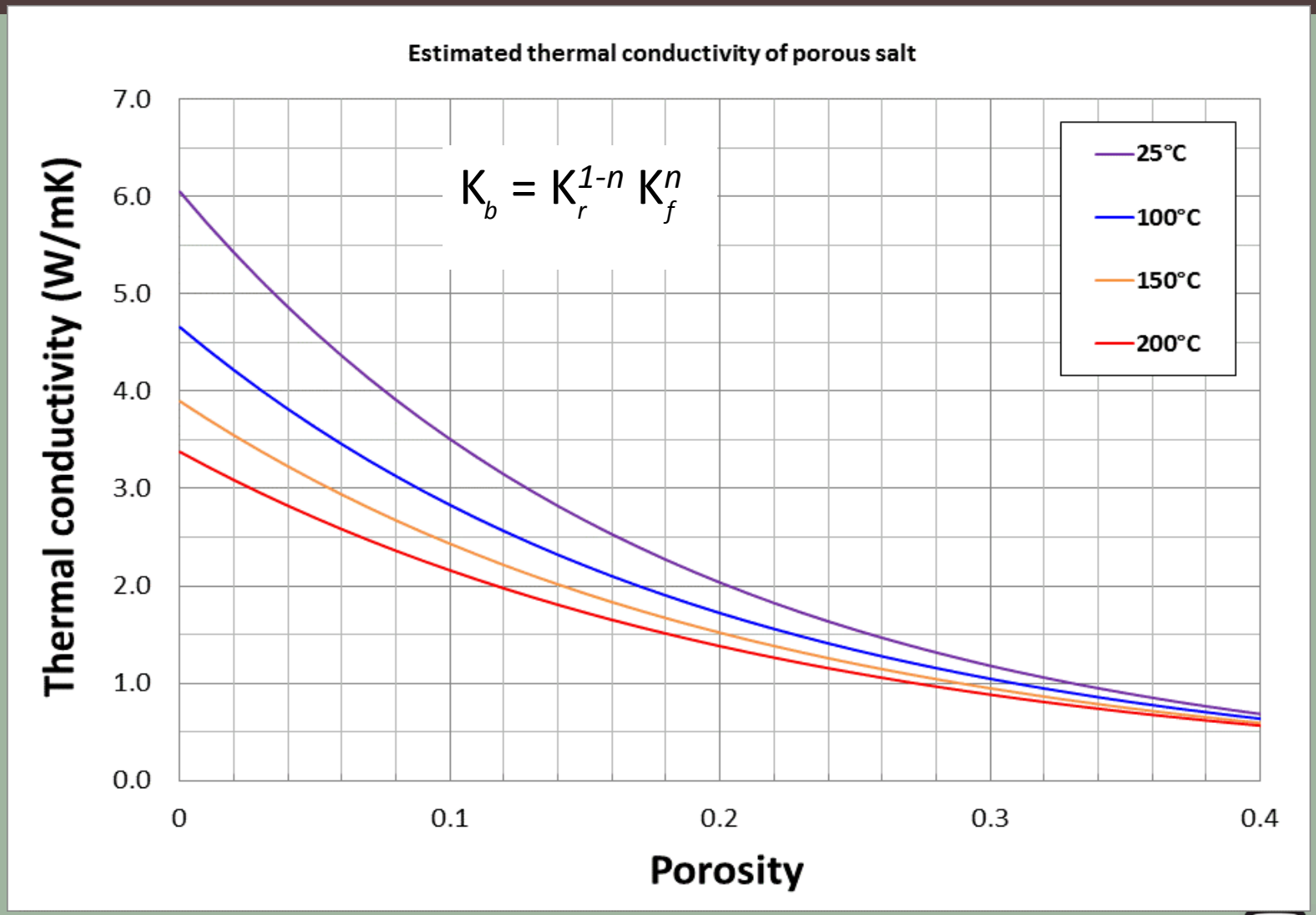
Porous salt model



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Summary of results

- Thermal conductivity of single crystal, domal, fractured, and porous salt has been determined for a temperature range of interest for nuclear waste disposal
- **K** decreases with increasing porosity
- A simple mixture theory model represents the **K** versus porosity rather well
- **K** decreases with increasing temperature
- **K** of fractured salt is less than intact salt
- As this bedded salt is heated, water is released

Conclusions

- Thermal conductivity of the backfill will increase as the crushed salt compacts under pressure, resulting in increasingly efficient dissipation of heat as time progresses.
- In a repository setting, water may be liberated by heating .
- In repository settings where salt has been fractured, the **K** will be less than that of intact salt of known porosity. Porosity estimates of the fractured salt can be made by comparing measured thermal conductivity to the **K** model.
- **K** data measured are close to **K** values predicted by simple mixture theory model at given porosities and temperatures. Model is a reasonable predictor of salt thermal conductivity over a range of conditions possible when disposing heat-generating nuclear waste in salt.

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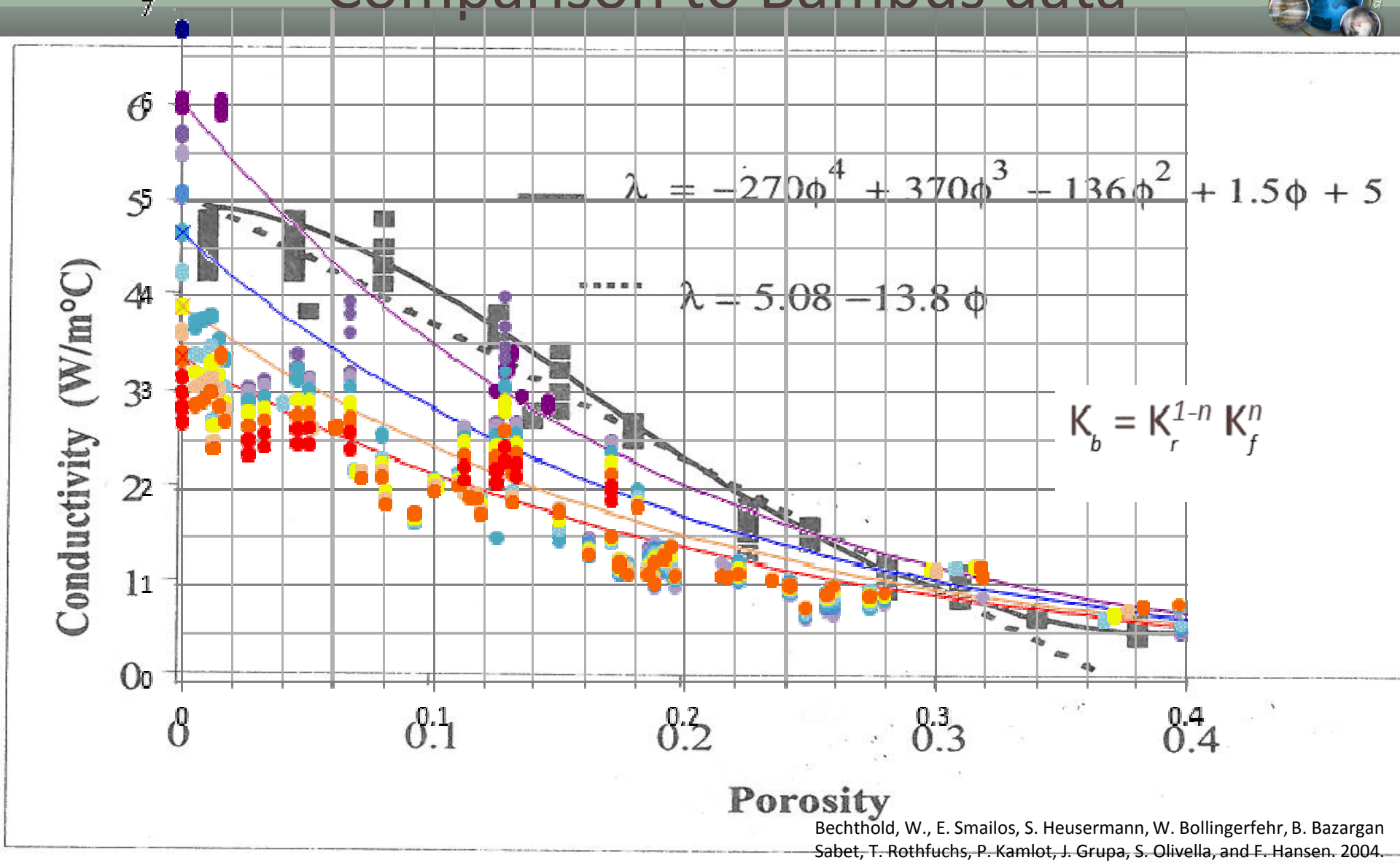
QUESTIONS?

Comparison to Bambus data



Bechthold, W., E. Smailos, S. Heusermann, W. Bollingerfehr, B. Bazargan Sabet, T. Rothfuchs, P. Kamlot, J. Grupa, S. Olivella, and F. Hansen. 2004. Backfilling and sealing of underground repositories for radioactive waste in salt (Bambus II Project): Final Report. EUR 20621 EN. European Commission, Luxembourg.

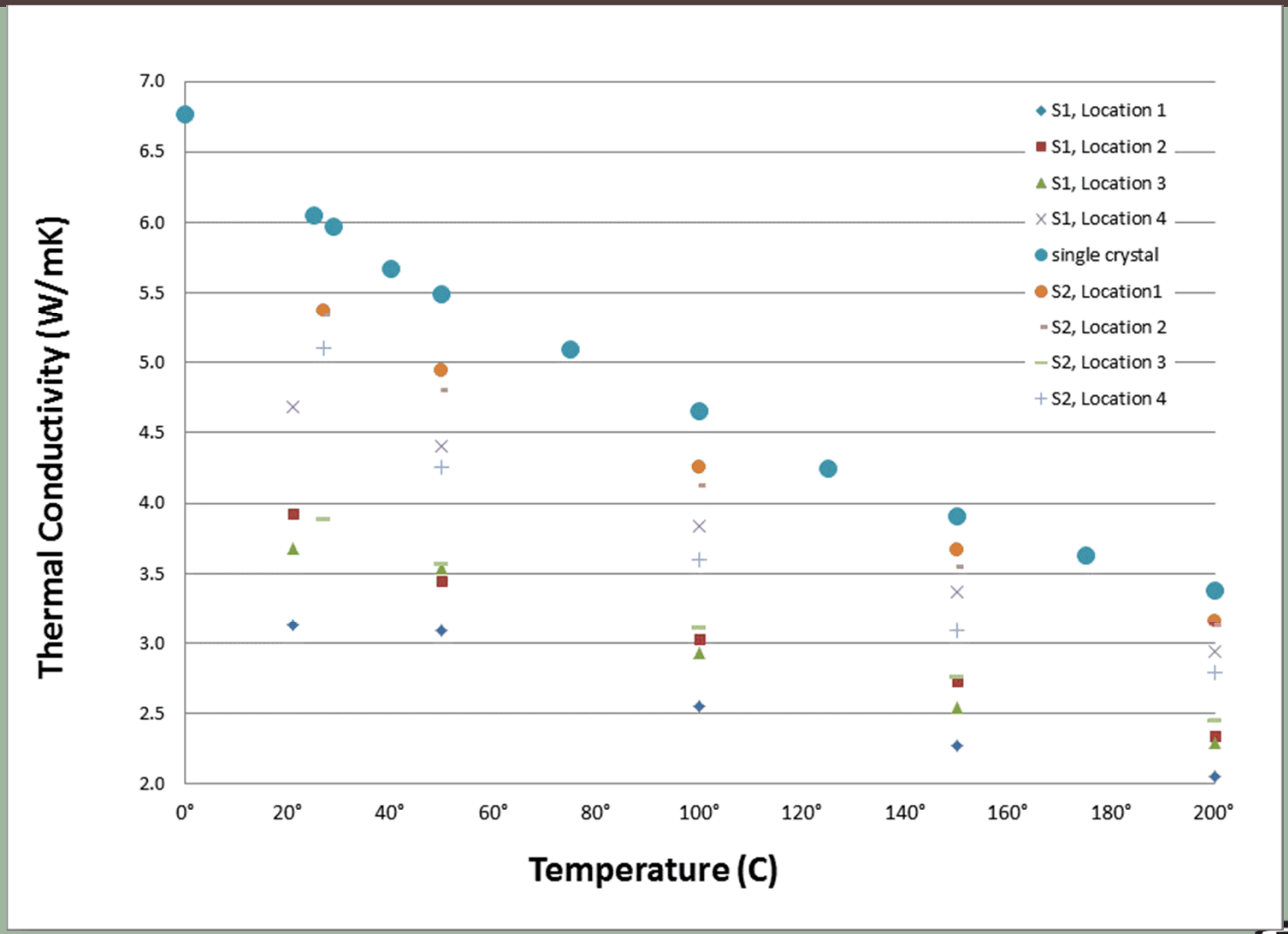
2.37: Backfill thermal conductivity versus porosity

Conclusions

Thermal conductivity

$$K_b = K_r^{1-n} K_f^n$$

Thermal Conductivity Fractured Salt



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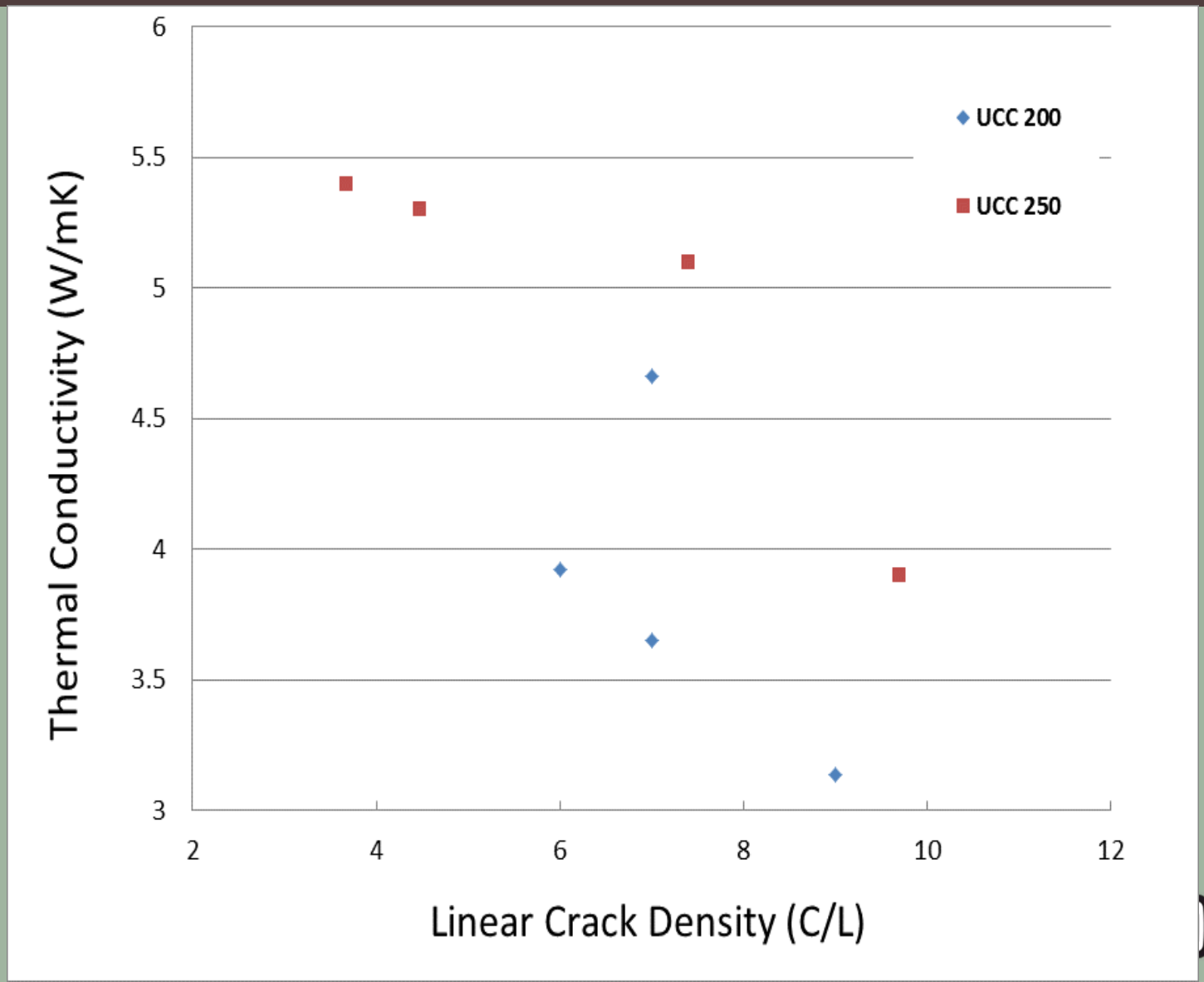
Linear Crack Density versus Thermal Conductivity



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