**Understanding the Irregular Data from the Large Block Test**

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## Research Objectives

The Large Block Test (LBT) is one of three thermal tests at Yucca Mountain, Nevada. While two of those three tests (the Single Heater Test and the Drift Scale Test) were large underground tests, the LBT was above ground. The test block, with a size of 3 x 3 x 4.5 m, has a highly heterogeneous permeability field, with at least four orders of magnitude variation in permeability. Some of the temperature data from the LBT appear irregular at first glance, but on closer examination can be attributed to this heterogeneous nature of the fractured block. In this project, we attempt to develop a better understanding of these irregular temperature data from the LBT.

## Approach

The test block in the LBT was excavated from the surrounding Topopah Spring fractured nonlithophysal tuff in the Fran Ridge area of Yucca Mountain. The bottom of the block remained attached to the underlying rock, while the top and the four side faces were kept open to the atmosphere. Mapping of all the fractures from the four sides and the top surface of the block revealed the existence of some large fractures in the block. The presence of such large fractures indicates that the flow of water and heat-induced vapor can be very different in different zones of the block, with vapor and water flowing more easily through the highly permeable fractures than elsewhere. It is our hypothesis that the irregular temperature data arise out of thermal-hydrological processes taking place in the heterogeneous fracture system. We show, through simulations performed with a 3D dual-permeability numerical model based on the TOUGH2 simulator, that such a heterogeneous fracture system can indeed give rise to irregular temperature data.

## Accomplishment

Comparison between measured and simulated temperatures in a vertical borehole (TT1) is shown in Figure 1. A thunderstorm occurred around 4,470 hours of heating in the LBT. As rain-water trickled down the fractures in the heated rock, complex thermal-hydrological processes occurred in its heterogeneous environment. Sensor TT1-28 is at the top of the block and Sensor TT1-1 is at the bottom of the block. Temperatures at Sensor TT1-28, originally at 60°C, went up to 100°C before declining to 60°C at the end of the rain event. However, Sensor TT1-14, which was at 140°C, fell sharply to 100°C before returning to 140°C. As rain-water came in contact with the heated rock (maximum temperature at Sensor TT1-14, closest to the heaters), it vaporized. As the vapor passed upward through cooler zones away from the heaters, temperatures at those locations increased to 100°C. Thus, though the temperature signatures appear irregular, they can be explained in terms of fracture heterogeneities, for which the model provides a good understanding.

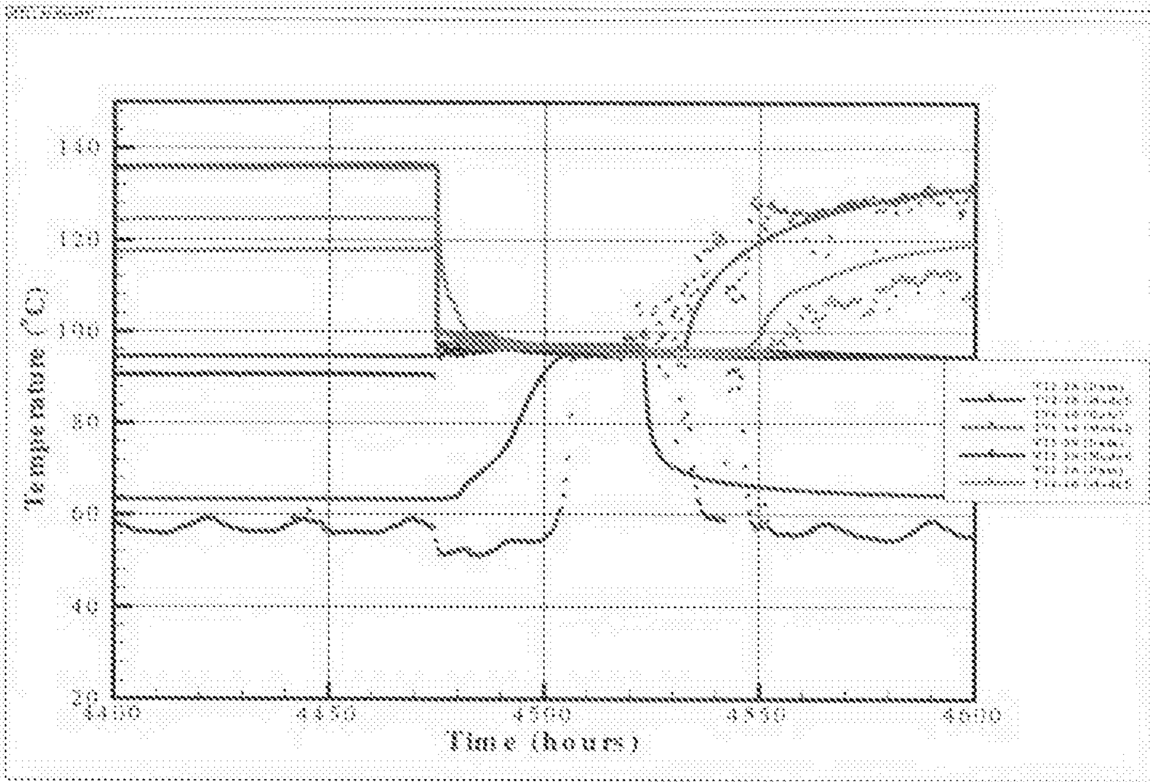
Temperature (°C)
20
40
60
80
100
120
140
4400
4450
4500
4550
4600
Time (hours)

Figure 1

**Significance of Findings**

The close match of data and simulations in this test indicated our increased understanding of thermally driven coupled processes in unsaturated heterogeneous fractured rocks.

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Figure 1 Comparison of measured and simulated temperatures at selected sensors of borehole TT1 in the LBT.