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**Third Quarter Results of
Infrared Mapping in the Single Heater Test Block**

Paul Cook and Joe Wang

Lawrence Berkeley National Laboratory

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Introduction

For the duration of the single heater test (SHT) the rock surfaces on the SHT block have been periodically examined using an infrared camera. This monitoring is performed to assess whether the thermal distribution from the heater can be observed on the block surface, to see if this can be related to any physical features known to exist in the block and perhaps to discover new features apparent only from thermal data. Such features could include surface outlets for pathways of fluids or gases that undergo thermally induced changes. This report compares the latest set of thermal data taken on May 22, 1997 to the previous three sets taken in August and December of 1996 and February 1997. The May data was acquired shortly before the heater was turned off. The February, August and December picture sets were compared and commented on in the Level 4 Milestone SP9237M4 "Infrared Imaging in the Single Heater Test Area", April 18, 1997. The techniques used in the latest data acquisition are improved to ensure minimal perspective error in the images and to allow for easier montage creation. Instead of a tripod support for the IR camera, a specially designed cart is now used to hold the camera at the desired angle to the wall and to allow controlled movement parallel to the wall. The IR camera is used to take pictures of the region above the heater collar, along the right side of the heater block and at the end of the extension drift. Figure 1 is a diagram showing the areas of the SHT that are under IR study. Frames in a given data set were taken from approximately the same distance, and perpendicular to the surface of interest. The ambient temperature in the single heater area for the May acquisition was 28.1 °C. For February the temperature was 27.2 °C, and in December was 25.0 °C. As before the temperature of a 100% emissive object in the vicinity was checked through the camera against a calibrated thermometer.

Data and Discussion

The focus for the new data set remains on the region above the heater collar where there is a halo of heat just above the insulation. In addition, attention is given to the right side of the block, also depicted in the diagram of Figure 1. As noted in the April milestone report, there is an indication of heat emanating from the right side of the block above the insulation.

Data is included from each of the previous sets in the current report to obtain a meaningful interpretation over time. In addition to presenting two-dimensional color-keyed or grayscale IR images it is useful to gather the temperature data along a line traced over some interesting region of the montaged images. These line plots can give more detail than montages when the focus is on a particular region and are able to highlight actual changes in magnitude better than a montage. Furthermore, with four data sets it is now reasonable to observe heating over time so the temperature history of selected points can also be presented.

Line plots are shown in Figure 2 for a line drawn across the montaged images of August, December, February and May of the SHT front face just above the insulation. Temperature is plotted against distance. The scale of the bottom of the plot represents the distance between the extensometer pins TMA-WX-2 and TMA-WX-1, left to right. This distance is roughly 4 meters centered on the single heater itself. Image 1, an IR montage from the February data is included to show the pins (marked with arrows). The trough in values in the center of the line plots corresponds to the image of a cable tray which radiates at room temperature. The dip is of different widths because the tray is an item far from the wall and subject to parallax error in the images. The magnitude and variation with position of the temperatures on the face appear to increase as the block gets hotter.

Figure 2 contains line plots of December, February and May temperatures taken just above the insulation on the right side of the SHT block from the top corner of the block to the rockbolt nearest the cable tray on that side (about half the length of the right side, 4 meters). Again, the increase in variation and magnitude can be observed as time progresses. The left side of the plot which corresponds to the corner shows cooler temperatures than the rest of the plot due to the higher exposed surface to volume ratio of the corner section. It is uncertain why there are two peaks in temperature along the top of the insulation. The first peak on the left could be a heat leak from the insulating blanket while the second corresponds to the depth of the heater unit from the front face.

It should be noted that the line data for May contains dropouts and that no montages for May have been included for this report. The images collected in May became partially corrupted when transferred from the camera to storage. The montages of May images are confusing to view due to artifacts of the corruption. However, about 30% of each corrupted image is fully intact with

correct pixel value and location and the corrupt sections can be safely ignored because these erroneously give the maximum pixel value and thus are easily identifiable as corrupt and do not displace any of the location information. The dropouts correspond to the erroneous pixel data. The intact sections are distributed in a regular pattern on each image allowing proper spatial cues for montaging and correct temperature readings from the good pixels. The file corruption therefore constitutes only a reduction in the amount of data but no reduction in the quality of the data.

Figure 4 shows the variation over time of some selected features on the SHT block. The locations of these features are shown relative to the color IR images in Images 2 and 3. These features are the “hotspot” above the insulation to the left of the heater on the front face, a rockbolt close above this hotspot and a rockbolt above the insulation on the right side near the corner. Ambient temperature is also included for comparison. The increase in temperature appears to slow down from December to February and then pick up again from February to May. This slowdown may be due to winter air in the vent system acting on the surface of the block. If so, then there is a lag time of the block surface’s response to the vent because the ambient temperature increases more rapidly during this period than that of the surface. Another explanation could be that the heating front that is moving to the surface has a thermal gradient that is not constant with depth.

The change in temperature on the right side of the SHT block between December and February that can be observed in the line plots was briefly alluded to in the April milestone. No images of this area were shown in that report so montages from these two months are included in this report. Montages from December and February of that right side area are shown on Plates 1 and 2. The line shown in the February montage on Plate 2 just above the insulation describes where the line plots for Figure 3 were obtained.

Data Status and Quality Assurance

All the images obtained in this study were performed by qualified personnel and the equipment used to obtain them calibrated under the LBNL QA program. All the acquired data including that from the May data set (with the exception of bad pixel values which are not used in any analysis) are to be considered qualified data.

Acknowledgment

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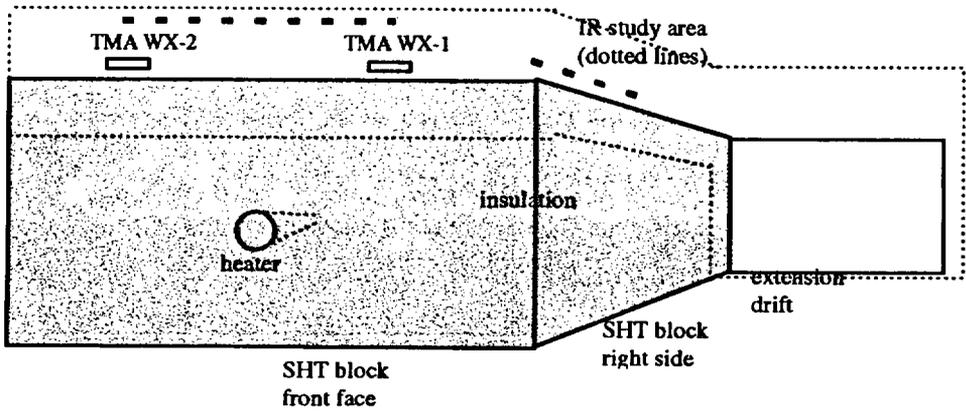


Figure 1 Diagram of IR study area at the SHT area

Heavy dotted lines indicate regions for study for temperature plot lines shown in Figures 2 and 3.

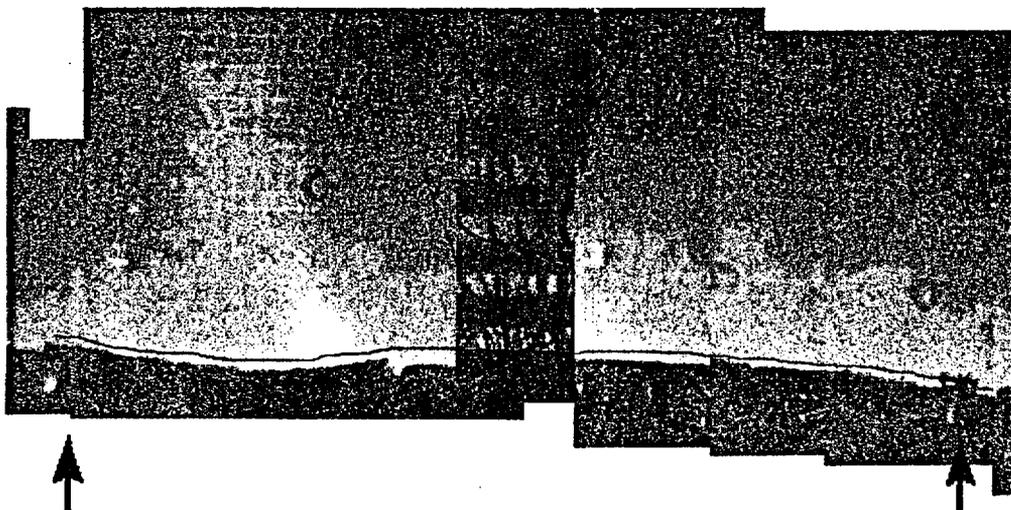


Image 1 Front face of the SHT block
 The line directly above the insulation indicates the approximate location of the data points for the line plots.

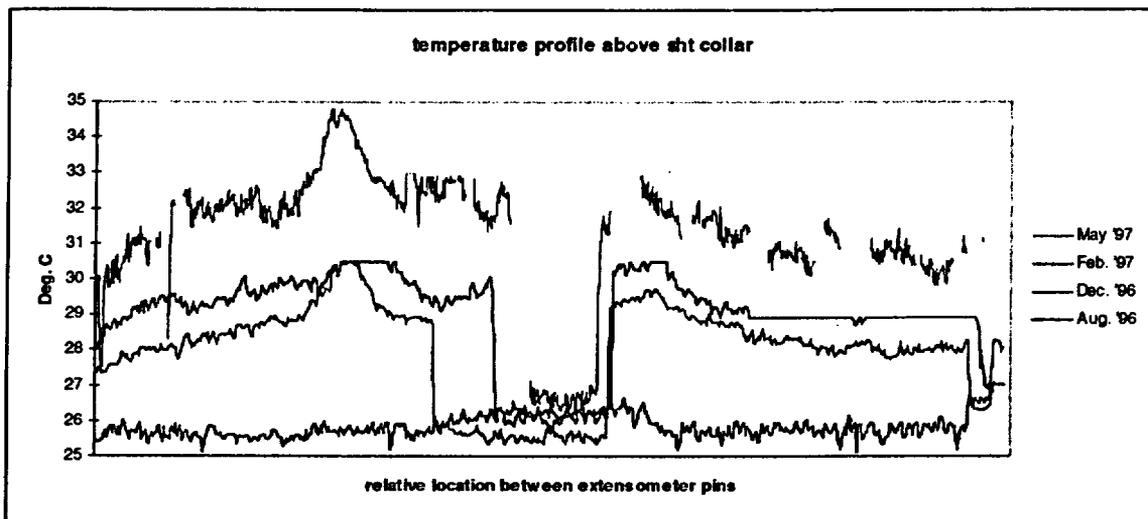


Figure 2 Line plots of the front face above the insulation

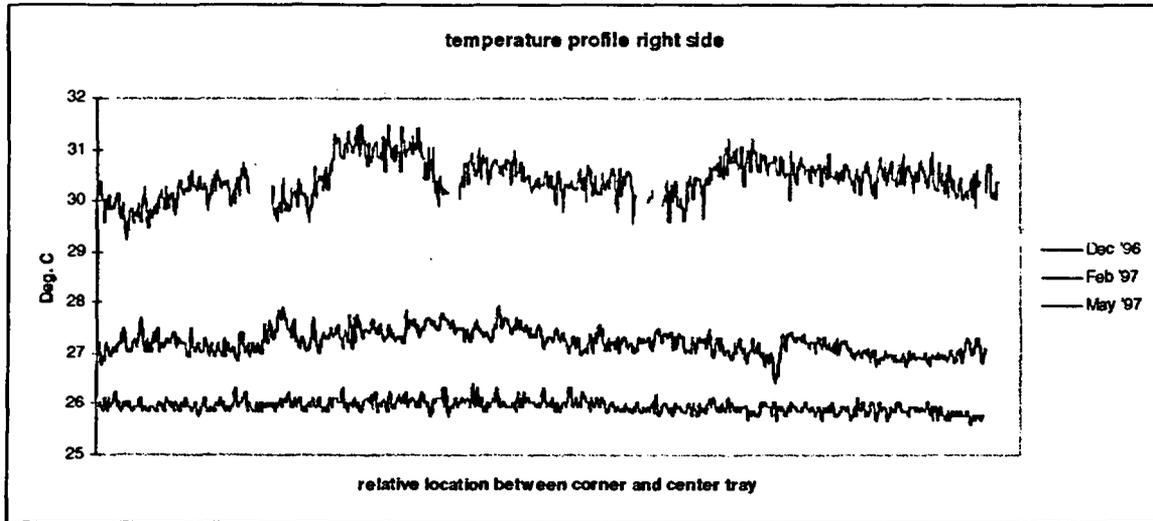


Figure 3 Line plots on right side above insulation from corner to center of block
See Plate 2 for line location.

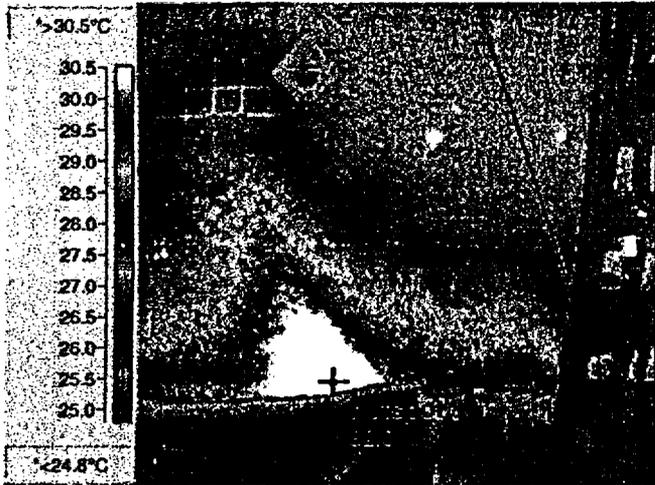


Image 2 Hotspot and rockbolt from front face



Image 3 Rockbolt from right side

temperature of selected points vs time

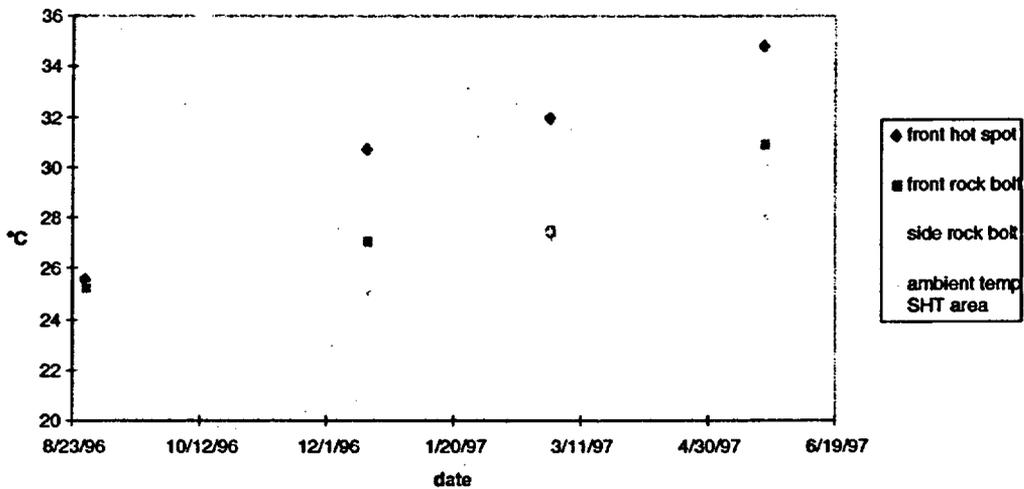
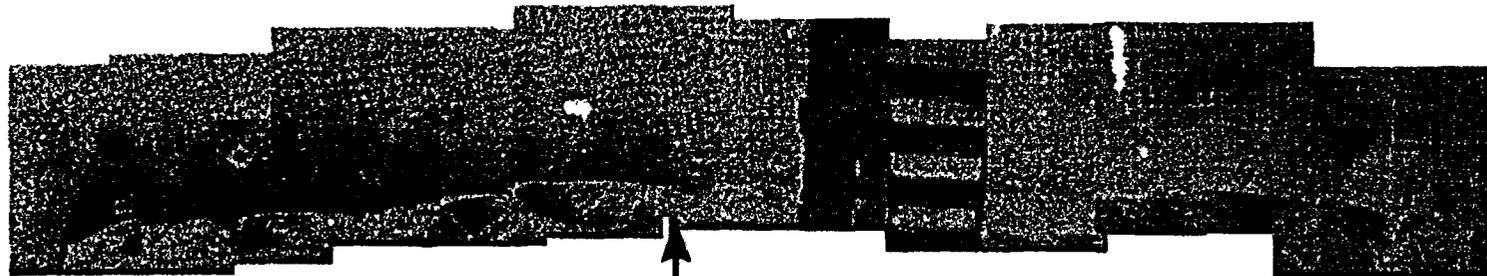


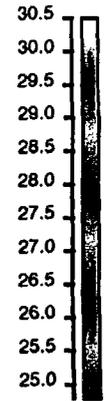
Figure 4

IR image right side SHT 12/17/96

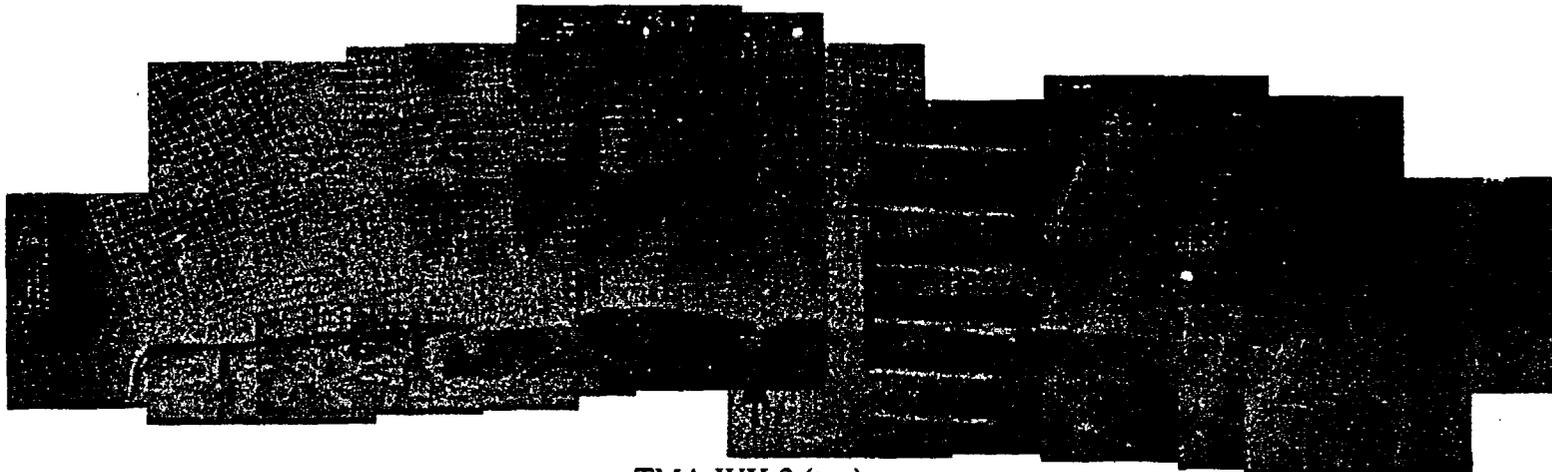


TMA-WX-3 (top)

>30.5°C



<24.8°C

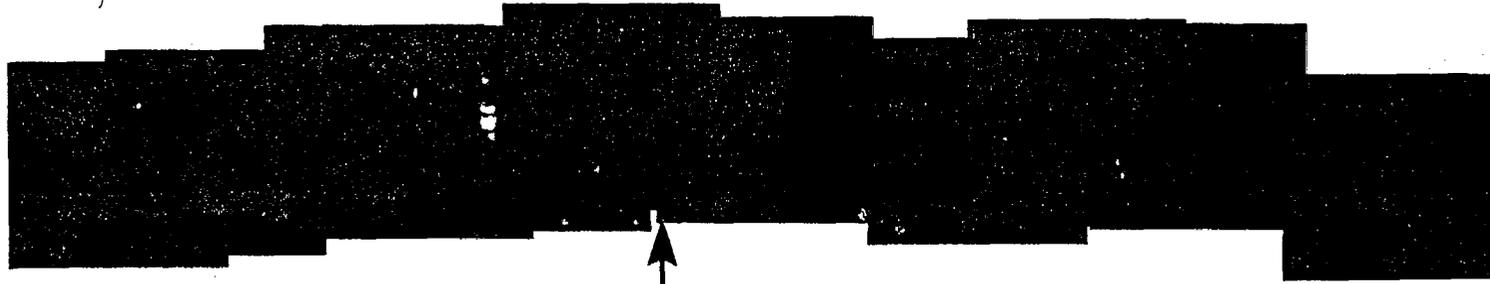


TMA-WX-3 (top)

IR image right side SHT 2/27/97

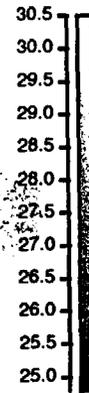
Plate 1

IR image right side SHT 12/17/96

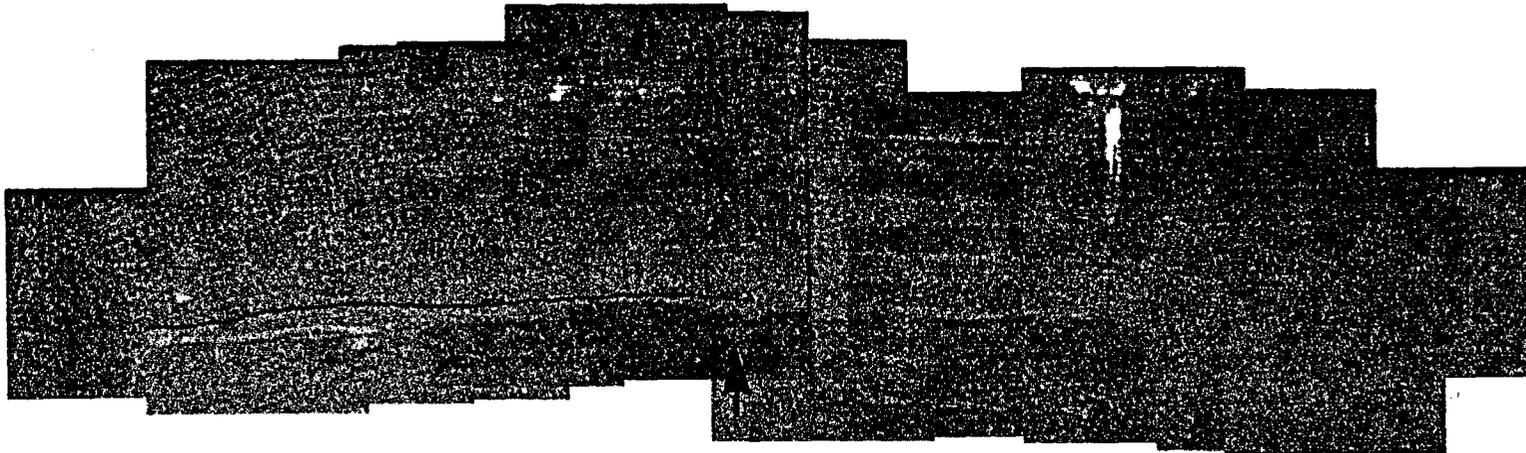


TMA-WX-3 (top)

>30.5°C



<24.8°C



TMA-WX-3 (top)

IR image right side SHT 2/27/97

Plate 2

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