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Pre-heat Baseline Infrared Imaging in the Drift Scale Test Area

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For the duration of the Drift Scale Test (DST), the rock surfaces on the "cold" side of the bulkhead near the Heated Drift (HD) and along the Access/Observation Drift (AOD) are to be periodically examined using an infrared (IR) camera to determine what effect the heater has on the rock surface temperatures. The monitoring surveys are performed to assess whether the thermal distribution from the heater can be observed on the rock surface, to see if this can be related to any physical features known to exist in the rock, and perhaps to discover new features apparent only from thermal data. Such features could include surface outlets for pathways of fluids or gases induced by thermal changes.

The AOD was chosen for IR study because it has a long, accessible surface, nearly parallel to the heater drift, as illustrated in Map 1, and also because it has been characterized using air permeability techniques. Because the AOD is predicted to be slow in its thermal response to the heaters due to its distance (~ 30 m) from the heated drift, the potentially fastest responding area, that of the bulkhead, was also chosen for IR study. The observation of changes in a thermal feature above the heater in the SHT face inspired the baseline study in the DST bulkhead area. Any thermal features to be observed near the bulkhead would likely be more easily detected to quantify heat transfer processes induced by the nearby heat source as opposed to the likely more subtle and long range thermally induced changes along intrinsic features that might be observed in the AOD.

This report concerns the baseline set of thermal pictures taken in May 1997. The baseline data will be compared with data taken later after the heater is turned on. Similar surveys are in progress in the Single Heater Test (SHT) area. The DST covers a much larger area than the SHT area. Furthermore, the drift walls in the AOD in DST are not planned to be covered with protective sheaths and IR images can be taken on all exposed surfaces. To establish an efficient approach for the DST surveys, a newly assembled IR/moisture monitoring mobile cart was deployed for this DST baseline study. With the camera and sensors mounted on the cart and with computer control to automate data collection, the efficiency for IR/moisture survey is much improved from earlier SHT surveys with hand-held IR camera operations.

The procedure for acquiring IR images involves using the cart-mounted IR camera to take pictures of the region along the walls and ceilings of the AOD and near the bulkhead area of the HD. Frames in a given data set were taken from approximately the same distance and perpendicular to the surface of interest. As before (Level 4 Milestone SP9230M4 "Infrared Imaging of the Single Heater Area, January 1997; Level 4 Milestone SP9237M4 "Second Quarter Results of Infrared Imaging in the Single Heater Test Block, April, 1997), the temperature of a 100% IR emissive object placed in the AOD was checked through the camera against a calibrated thermometer. The temperature readings from the IR camera is calibrated against known temperature standard. Rock surfaces near the 100% emissive object have nearly the same temperature readings by the IR camera, indicating that rock surfaces have nearly 100% emissivity value. The ambient temperature in the AOD at the time of acquisition was 26°C. The ventilation in the area was on during the survey, with the relative humidity in the AOD of 30-33%. Spatial references for images are taken from the rock bolts and borehole collars. Later in the study, a dedicated metallic frame with special heat reflective tape may be mounted along the AOD and in other interesting locations near the HD bulkhead to provide extra spatial references in the IR images.

The thermal images cover roughly 1 square meter each at the distance from which they were taken and each contains 256 X 256 pixels stored in 12-bit digital format. The camera was focused manually. The IR intensity from each pixel is converted into real temperature readings using the emissive object and the known range of the camera. The temperature resolution per pixel is 0.1°C. Individual frames can be manipulated to correct for emissivity and background radiation so as to match independently known temperatures of objects in the images. As currently used, these adjustments are not altered from default and are held fixed for all images so that meaningful comparisons of temperature over time can be made. Spot measurements of temperature can be taken for given features. For better visual cues of the temperature distribution, the images, which in their native form are grayscale, can be arbitrarily color-keyed to match a desired colored temperature legend.

The rock bolts provide a radiant conduit for heat from beneath the rock surface to the camera and so give a truer indication of the rock temperature than does the surface of the rock which is subject to the influence of tunnel air convection. Open borehole collars, should they remain, would provide the best below surface black body features however.

Over 200 IR images were taken in this survey with four traverses to cover the AOD walls, mainly covering strips along the wall-ceiling junction and around the bulkhead. Note that no large montages of IR images for the AOD or bulkhead area are included in this report since the images taken so far are purely for baseline data and will be used to compare to data acquired after the heater is turned on, scheduled for December 1997. Some individual frames are included as examples to highlight a problem caused by extraneous light sources (Figure 1), to present an example with rock temperature different from the mesh and rockbolt temperatures (Figure 2), and to illustrate the coolness of the boreholes in the AOD (Figure 3). The possibility of taking IR images with a robotic cart traversing the drift in the dark will be evaluated to address the light interference problem illustrated in Figure 1.

After the boreholes in AOD are instrumented for the DST heater test, IR images will be taken of borehole collars to assess the remaining IR contrast between borehole and surrounding rock wall surfaces, as illustrated in Figure 3. The borehole collars as black body features are planned to be used for spatial references in the IR surveys, if boreholes do not become heat transfer pathways from the heated drift to the AOD and other outside walls.

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 data presented are to be considered qualified data.

Acknowledgment

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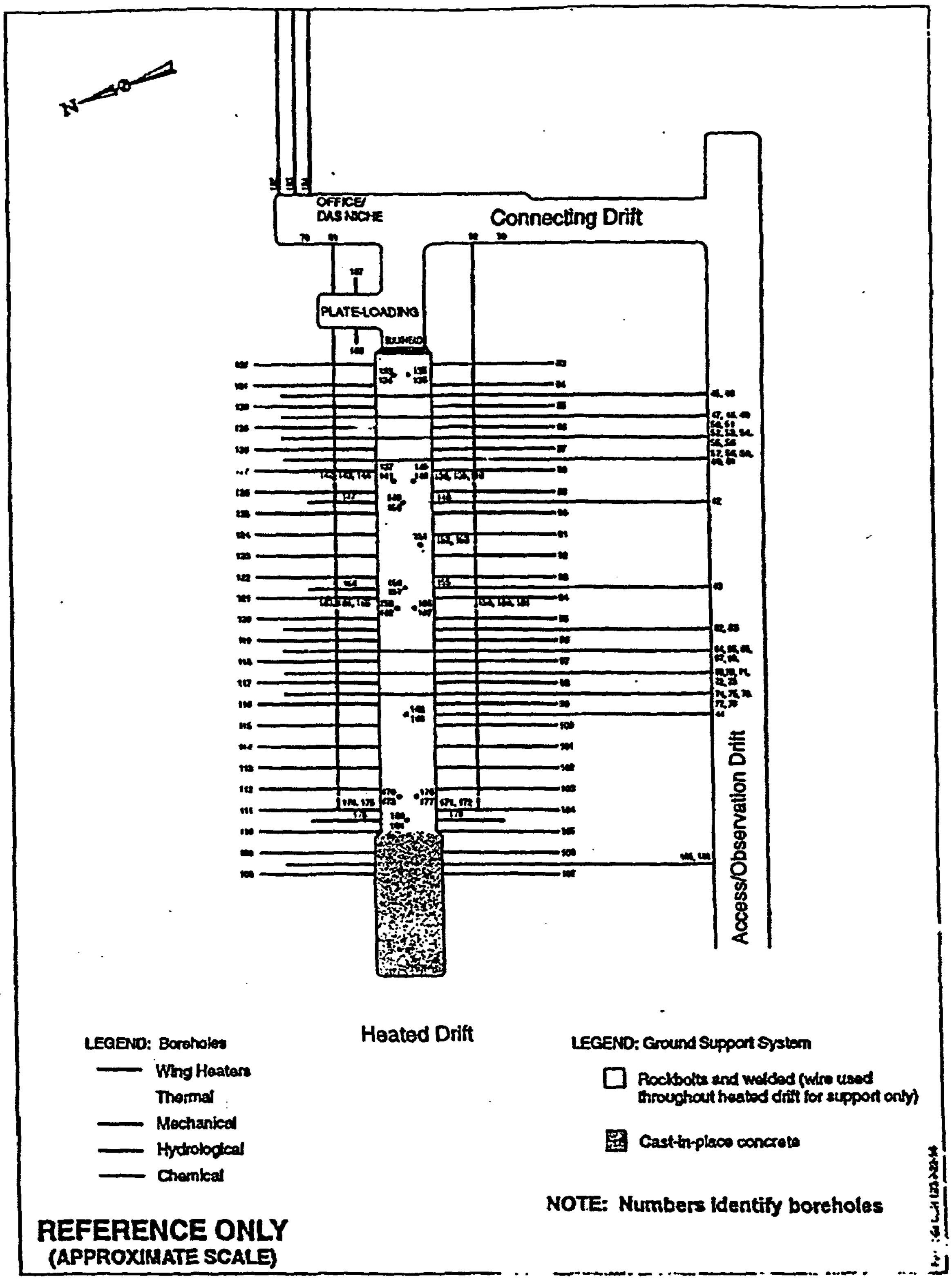

MAP 1: Layout of the Drift Scale Test Area

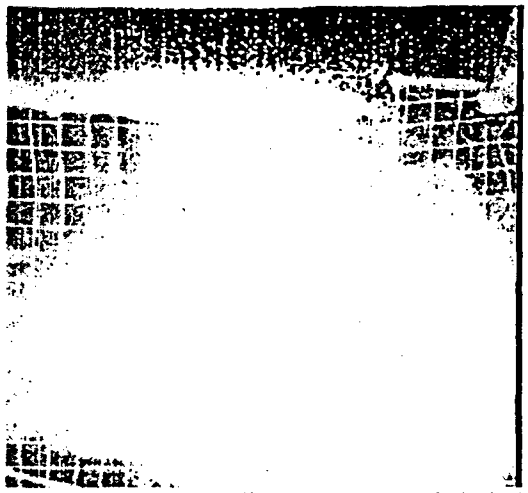

Figure 1. Fluorescent lights leave an IR halo in image.

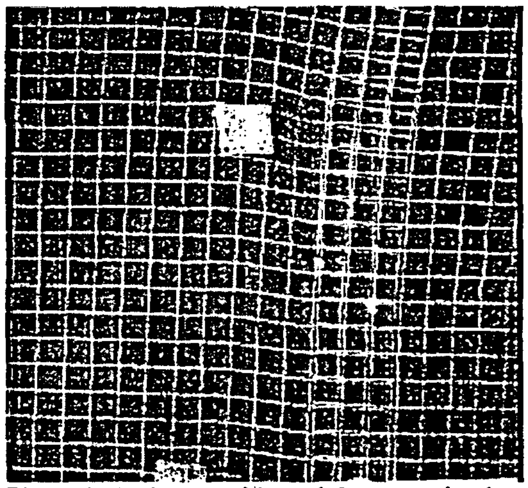

Figure 2. An image with no light contamination

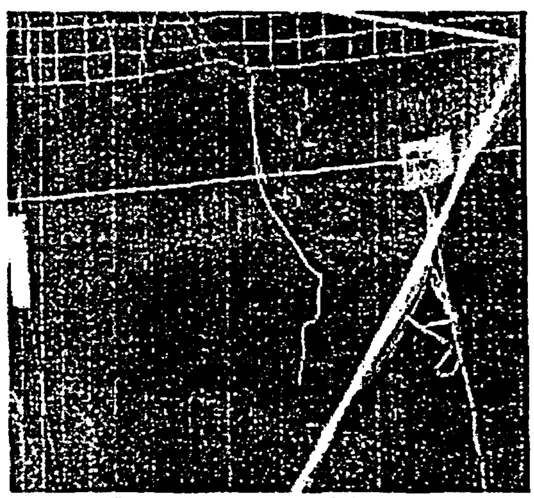

Figure 3. Borehole on lower right of image appears cool.

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