STANDARD OPERATING PROCEDURE NO. 51

COLLECTING THERMAL IMAGES

REVISION LOG		
Revision Number	Description	Date
51v0	Original SOP by HRS and JMS	6-7-2004
51v1	Finalized by LMK to post on Molycorp project website and to send to George Robinson for lab audit; LMK did not edit this SOP	4/3/07
51v2	Editorial by SKA	10/27/08

1.0 PURPOSE AND SCOPE

This Standard Operating Procedure (SOP) provides technical guidance and procedures that will be used to collect images of temperature differences on the surface of the rock piles and other areas. The SOP describes how to set-up the tripod and thermal camera, collect the images together with the data necessary to correctly analyze them, conduct the analyses, and archive the digital files of the photographs. By displaying temperature differences on the ground surface, the thermal camera is a useful tool in detecting zones where heat and possibly gases may be leaving the rock piles or in detecting stratigraphic layers that are distinguished by temperature. The SOP addresses equipment, field procedures, field data collection, and personnel responsibilities.

Measurement and imaging of variations in heat, called thermography, is a routine practice for industry, e.g., manufacturing, preventive maintenance, security, and science. According to the Stefan-Boltzmann law, any object at equilibrium with a temperature above absolute zero emits heat energy (radiation) across a range of wavelengths in the infrared radiation (IR) spectrum and that energy is proportional to some power of its temperature [Hillel, 1998] and an emissivity coefficient, ε. Varying between 0 and 1, the emissivity coefficient compares the object's ability to emit heat energy to that of a blackbody, a perfect emitter that does not reflect heat energy. An object's emissivity coefficient is not necessarily constant for all wavelengths of emitted radiation, but if its ε does not change with wavelength, the object is called a graybody. Although few objects behave as blackbodies and therefore reflect some energy, the radiation spectrum emitted by the sun, our primary source of heat energy, is fortunately rather different than the longer wavelength spectrum emitted by most objects at environmental temperatures [Hillel, 1998]. Thus it is possible to determine the temperature of an object at a distance with a thermal camera which utilizes the Stefan-Boltzman law, a variety of assumptions, and a known emissivity coefficient.

2.0 RESPONSIBILITIES AND QUALIFICATIONS

The Team Leader and Characterization Team will have the overall responsibility for implementing this SOP. They will be responsible for assigning appropriate staff to implement this SOP and for ensuring that the procedures are followed.

All personnel performing these procedures are required to have the appropriate health and safety training. In addition, all personnel are required to have a complete understanding of the procedures described within this SOP, and receive specific training regarding these procedures, if necessary.

All environmental staff and assay laboratory staff are responsible for reporting deviations from this SOP to the Team Leader.

3. DATA QUALITY OBJECTIVES

This SOP addresses the following objectives in the data quality objectives outline by Virginia McLemore for the "Geological and Hydrological Characterization at the Molycorp Questa Mine, Taos County, New Mexico”.

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4.0 RELATED STANDARD OPERATING PROCEDURES

The procedures for taking photographs set forth in this SOP are intended for use with the following SOPs:

- 1 Data management (including verification and validation)
- 2 Sample management (chain of custody)
- 4 Taking photographs

5.0 EQUIPMENT LIST

The following materials and equipment are needed for taking photographs:

- FLIR SYSTEMS ThermaCAM SC3000 NTSC
- Heavy-duty camera tripod
- PCMIA ATA (RAM) card
- SONY Video Walkman Video Cassette Recorder and video cable
- SONY InfoLITHIUM Battery Pack (7.2V 21.6 Wh) and SONY AC Power Adapter
- FLIR SYSTEMS ThermaCAM Remote Control
- Power supply for thermal camera, HiTRON Electronics Corp., model HES61-11B
- DC/AC power inverter for car battery or auto DC outlet (cigarette lighter)
- car battery or alternative power source
- extension cords (when necessary)

- flashlights (when necessary)
- measuring tape
- thermometer
- hygrometer (measures relative humidity)
- field notebook
- field sample forms
- photo ID forms
- digital camera (optical)

The following materials are required for analyzing the photographs (away from the field);

- field notebook
- photo ID forms
- sample forms
- ThermaCAM Researcher 2000 software

6.0 PROCEDURES

Whether thermal images are captured for rapid surverys or detailed mapping, the necessary supporting measurements are the same, but camera set-up and use may differ. Rapid surveys are used to identify potential heat anomalies within a large area, such as a slope on a rock pile. Detailed mapping along one or more transects is required to accurately determine the extent and magnitude of the heat anomaly. Capture of overlapping images at regular angular intervals can allow construction of a panoramic composite image or map. An optical panoramic composite should also be made to help identify and relocate specific features of the heat anomalies. All thermal image capture with the instruments listed above requires measurements of the ambient temperature and relative humidity as well as the distance to the locations imaged. As the thermometer and hygrometer must be allowed sufficient time to equilibrate, these measurements should begin immediately while the tripod and camera are set up and distance measurements are collected.

Thermal image capture should be carried out during times or seasons which provide the greatest difference between ambient temperature and the temperature of any heat anomaly of interest. Heat anomalies with higher temperatures than the surrounding environment should be imaged when ambient temperatures are lowest, such as in the winter or late at night. Marking transects for detailed mapping at night will be more efficient and hold less safety risk if it is completed during daylight prior to image capture.

Thermal cameras are very sensitive and very expensive instruments. Always handle them with great care. Do not attach the camera to the tripod during windy conditions without adequately securing the tripod.

1. Select desired region to be photographed.
2. Begin measuring the temperature and relative humidity with the thermometer and hygrometer by allowing the instruments to equilibrate. After initial equilibration, record the time, temperature, and relative humidity in the field notebook. Also record any significant changes in either variable during image capture.

3. Insert flags or tape markers into the ground to mark out the beginning and end of each transect along which photographs will be taken. Collect UTM coordinates for the transect ends using a handheld GPS. Additional flags or markers should be placed at regular or known intervals within the transect for detailed mapping.
4. Measure the distance between the two end markers and any other markers or flags within each transect line. Record the distances in a field notebook.
5. Set up and level the tripod in the most appropriate location with respect to the surface to be photographed.
6. Set up the thermal camera on top of the tripod and attach the power, remote control, and video out cables. See Figure 1 and the camera manufacturer's instructions.
7. Ensure that the PCMIA card is inserted within the thermal camera.
8. Use the remote attached to the thermal camera to create a new directory on the PCMIA card.
9. Tilt the camera to take a photograph of the sky. Save the image and record the temperature as the atmospheric temperature in the field notebook.
10. Tilt the camera back to face the desired surface to be photographed. Record the tilt angle of the camera using the markings on the tripod head, a protractor, or similar device.
11. Measure the distance from the camera to the flags at the ends of the transect and any within the transect and record them in the field notebook. Repeat this step each time the camera is moved. Also measure and record the distances to any selected features within the transect area.
12. Take a GPS measurement at each camera location. Record the location on the field sample form and in the field notebook.
13. Enter in the ambient temperature, relative humidity, atmospheric temperature, and distance to the center of the first image using the remote control.
14. Begin capturing images. Change the values of the ambient temperature, relative humidity, and distance as needed for each new image using the remote control. In the field notebook, record the first image number in a sequence of consecutive images, or record each individual image number that is associated with a different location. The image numbers are file names assigned by the camera's software and will be used to connect the field locations with the image files when post-processing the images.
15. If optical photos are also to be captured, remove the thermal camera from the tripod, carefully replace it in its case. Attach the optical camera to the tripod, and begin taking photographs. If a panoramic composite is to be constructed, capture a sequence of overlapping images at regular angular intervals. For example, the transect could be encompassed with six photos with a constant angular interval of 20 degrees.

7.0 DOCUMENTATION

- Record field location and description, date collected, time collected, GPS location, atmospheric temperature (sky temperature), ambient temperature (air temperature), relative humidity, distance from surface photographed, tilt angle of the camera, the distance over which the images were obtained, and the initials of the person collecting the sample on the sample form. Image files should be clearly identified as raw, post-processed, single, or composite when they are shared or archived.

8.0 QUALITY ASSURANCE/QUALITY CONTROL

Routinely check the accuracy of the thermometer and hygrometer. Verify the emissivity of the surface materials in the laboratory when the analysis requires determining whether small differences in heat radiation are actual rather than apparent.

9.0 References

Figure 1: Instrument set-up

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