

Thermography Report Noah's Ark - NUH_UN GEM1

Key Terms: FLIR, thermography, infrared, electromagnetic spectrum, sUAS, emissivity

To conduct a thermal survey of areas of interest (AOI) along the East and West rim of the feature, the ToPa 3D documentation team used a FLIR Vue Pro R – 7.5 Hz radiometric thermal sensor. The sensor is designed for use with small unmanned aerial system (sUAS) [drone] vehicles and employees a 13 mm lens which provides a field of view (FOV) of 45° horizontal x 37° vertical which produced a 640 x 512-pixel thermal JPEG image. The sensor operates in the longwave infrared (LWIR) portion of the electromagnetic spectrum (7.5 to 13.5 μm) and has an accuracy of +/- 5° C or 5% for a measurement in the -25° C to +135° C range.

Initial plans involved two aerial surveys at each AOI, one to be conducted at dusk (after sunset) and the other at Dawn (before sunrise). This is the ideal methodology used for archeological purposes as it allows for the creation of a temperature difference map to highlight features which show a different heat diffusion rate to the surrounding material. However, restrictions emplaced on the operation of sUAS vehicles at the time of study by the Turkish government prevented this initial plan from being utilized. Therefore, an alternative approach was used by the documentation team.

In lieu of the aerial surveys, the documentation team used the sensor to conduct ground-based thermal surveys of the AOI. This consisted of using the sensor in a hand-held fashion and walking parallel to the AOI at ~ 10 m distance with the sensor pointed horizontally at the target surface to try to minimize the amount of horizon/sky present in each thermal image. Data collection took place on 10/17/2019 from 5:53 AM to 6:03 AM and 6:05 AM to 6:30 AM. Only one survey was conducted at each AOI due to time constraints and limitations caused by the ground-based approach. Images were taken in ~ one second intervals and camera-based atmospheric corrections were applied. Additionally, images were corrected using an estimated average emissivity value (0.85) for the AOI.

The thermal images were pre-processed using FLIR Tools software to apply a uniform temperature scale based on the relative minimum and maximum temperature found in each thermal image set. This was done to try and improve the visual resolution of the images by minimizing the effect of infinite negative signals caused by the presence of the horizon or sky in images (Figure 1). A relative temperature scale of -12° C to 9.7° C was used for the 5:53 AM dataset (Figure 2) and -9.8° C to 11.7° C for the 6:05 AM dataset (Figure 3). This gives a relative temperature scale of -12° C to 11.7° C between both datasets. Once an appropriate uniform temperature scale was applied the images were processed using Pix4D Mapper to create a 3D thermal point cloud and mesh model of each AOI.

Interpretation of the data was not possible due to issues caused by the limitations in acquisition (e.g. inability to conduct aerial-based survey appropriate for such a project, insufficient number of surveys for comparison, horizon/sky effect on temperatures in images). Additionally, the time of year, and the soil type at the site, may not have been suitable for such a thermal survey. For thermal archeological surveys of this kind a semi-saturated soil (i.e. non-arid) is needed.



FLIR Vue Pro Thermal Imaging Camera for Commercial sUAS with 13mm Lens (7.5 Hz)

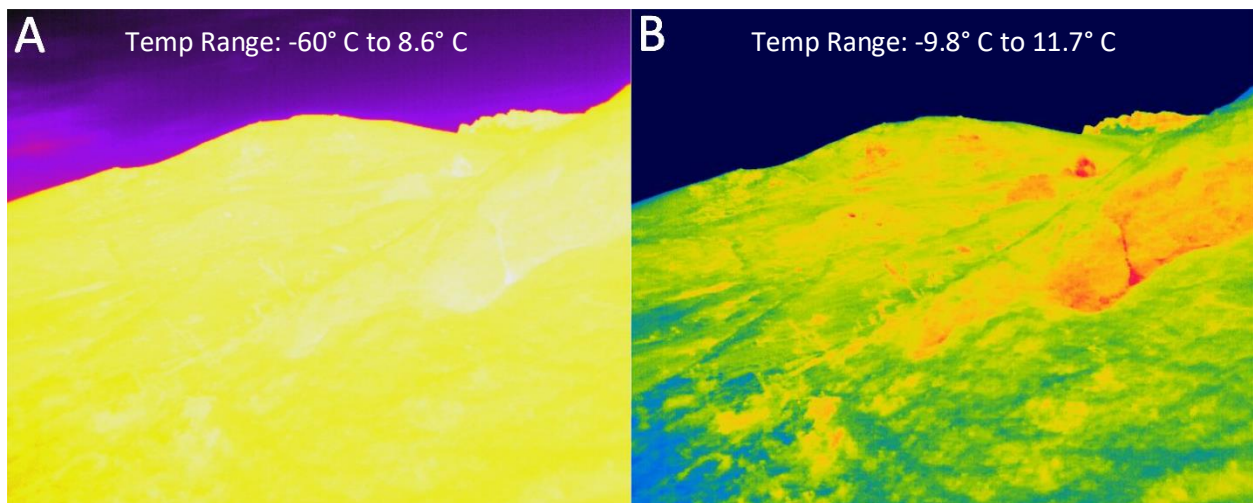
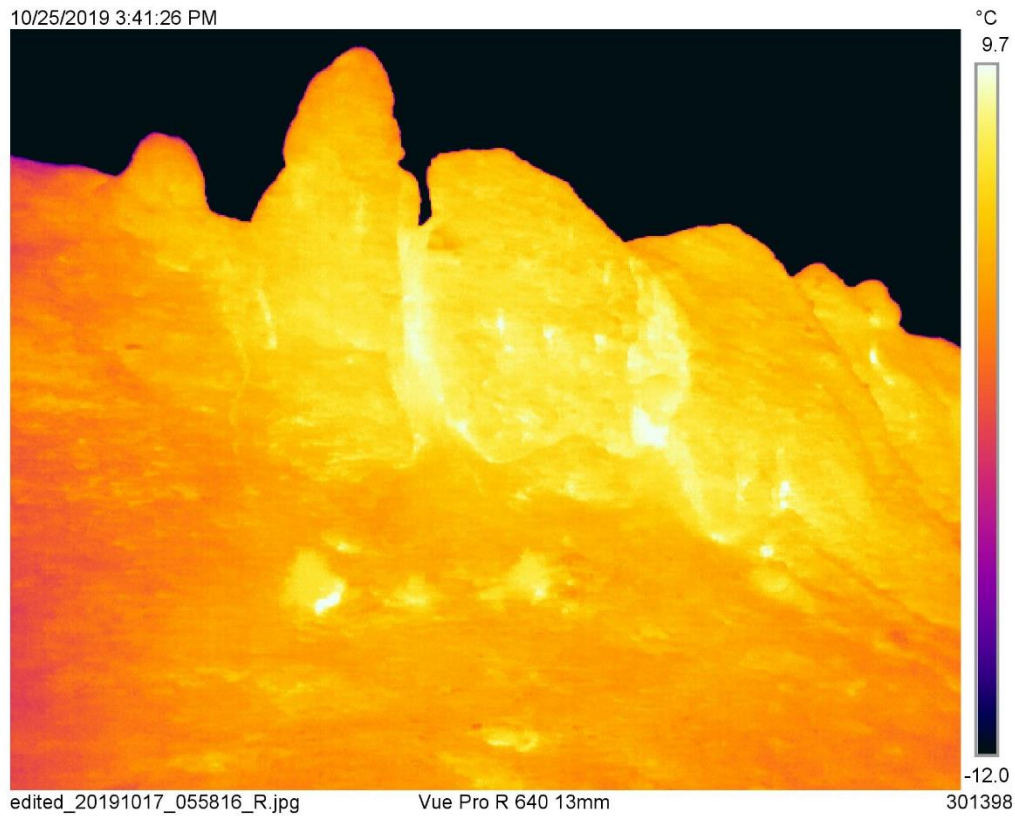


Figure 1 – 06:05:57 thermal image. The effect of horizon/sky in the thermal images required that a uniform temperature scale be applied to the images to improve feature resolution. Image A shows the raw, unprocessed image while image B shows the same scene after the application of the uniform temperature scale. Temperature scale for this dataset was -9.8° C to 11.7° C.



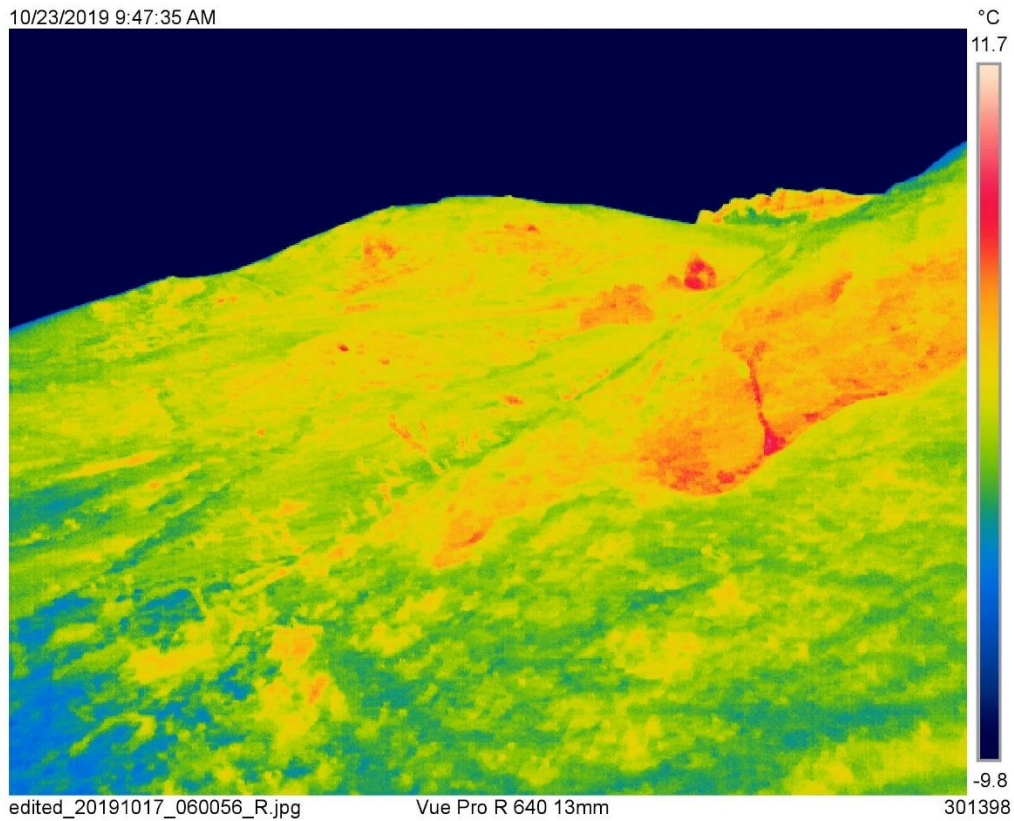
Parameters

Emissivity	0.85
Ref. temp.	7 °C
Distance	10 m
Atmospheric temp.	22 °C
Ext. optics temp.	22 °C
Ext. optics trans.	1
Relative humidity	45 %

Geolocation

Location	N 0° 0' 0.00", E 0° 0' 0.00"
http://maps.google.com?z=17&t=k&q=0.0000,0.0000	

Figure 2 - Sample image and FLIR tools report for the 05:53 AM thermal dataset.



Parameters

Emissivity	0.85
Refl. temp.	7 °C
Distance	10 m
Atmospheric temp.	22 °C
Ext. optics temp.	22 °C
Ext. optics trans.	1
Relative humidity	45 %

Geolocation

Location	N 0° 0' 0.00", E 0° 0' 0.00"
http://maps.google.com?z=17&t=k&q=0.0000,0.0000	

Figure 3 - Sample image and FLIR tools report for the 06:05 AM thermal dataset.