RAZ-IR Thermal Imaging Camera Evaluation – Bean’s Cove, PA
by Dave Decker

On 21 September, 2011 I was contacted by Dr. Lynn Rose for help in locating the entrance to a cave that had either collapsed or been filled in with rubble and then intentionally buried with dirt. I suggested several methods for locating the cave entrance, but we settled on using thermal imagery based on the assumptions that the cave air would be warmer than the ambient air temperature in the winter, and that an approaching low pressure system would draw out the warmer cave air, heating the rock and soil directly adjacent to where the entrance used to be. We decided on the Sierra Pacific Innovations (SPI) RAZ-IR Thermal Imaging Camera (Figure 1) based on its small size, light weight and ruggedness. I contacted SPI and had several discussions with one of their sales representatives, Mr. James Foley[1]. He agreed to send the unit to me for a two-week evaluation period, during which time I would do a proof-of-concept test down in the Guadalupe Mountains of New Mexico and then attempt to find the buried cave entrance in Pennsylvania.

Figure 1. Photo from RAZ-IR Nano Thermal Camera System User's Manual

The camera arrived just before New Year’s Eve and I was quite surprised at the accessories that came with it. The camera itself, two lithium-ion batteries, a charging unit with six different plug styles for use all over the world, a remote control, a rubber protective case and a thumb drive with analysis software and the user’s manual on it, all came inside a hard protective case with custom foam rubber cutouts. Additionally, both a fanny-pack sized soft-sided carrying case and small, faux-leather camera case came with the camera as well! The final bonus was the laminated contact card with both email and

---

[1] Sierra Pacific Innovations Corp. 6620 S Tenaya Way, Ste 100, Las Vegas, NV 89113, 702.369.3966 Fax 702.369.3977, jfoley@x20.org

phone numbers for free technical support if there were any problems or questions regarding the operation and set up of the camera or analysis software.

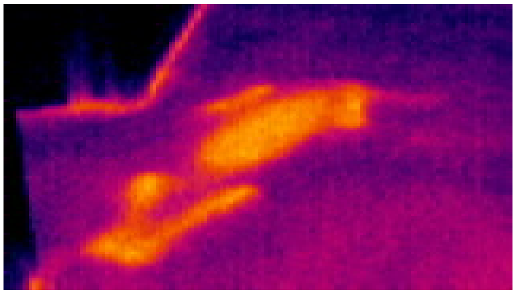

Figure 2: My dog was lying here five minutes before I came through with the RAZ-IR.

Before taking it down to the Guadalupe Mountains for its test run, I wanted to learn how to use the camera, so I turned it on and started walking around the house with it. Immediately differences in surface heat jumped out at me. Cool air flowing in through the windows, warm light switches and electrical outlets, people, hand prints and even a spot where a dog had been lying five minutes before (Figure 2)! Needless to say I was impressed by the quality of the small camera's display and its ability to pick up both obvious temperature differences and thermal remnants. The RAZ-IR was also very easy to use right out of the box. Most of the features are intuitive, and a quick read of the user's manual will bring the rest of the features within reach easily.

During the week of January 3rd, 2012, I conducted the proof of concept with the RAZ-IR at several caves in the Guadalupe Mountains in southeastern New Mexico. The ambient air temperature was approximately 11°C (54º F), while the cave air temperature was approximately 23°C (78º F). Figure 3 shows a split image of the entrance to Virgin Cave

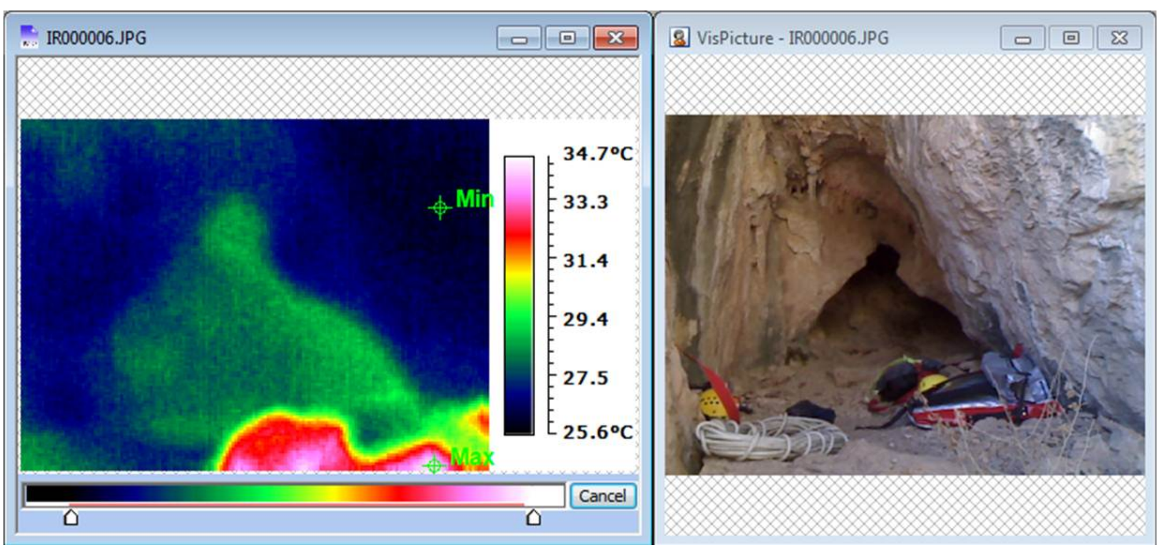

Figure 3: Thermal and visual image of entrance to Virgin Cave in the Guadalupe Mountains, NM.

(thermal image on the left, visible light image on the right). The day was clear to partly cloudy with ten knots of wind from the south. The cave entrance faces north and was in shadow at the time of the reading. As can be seen from the photo, the exterior walls surrounding the cave entrance are cooler (near ambient temperature) compared to the interior walls and adjacent rock, which are warmer and near cave temperature. This success during the proof of concept encouraged me to believe that if there was a missing cave to be found, we could do it with this technique.

The week of January 10th dawned cold and crisp. Dr. Rose, her mother Emma Jean Rose, Barbara am Ende and I arrived at Bean's Cove, PA at 6:30 AM. It was still dark, but clear, with an air temperature of -6.5°C (19° F) and frost on the ground. The study

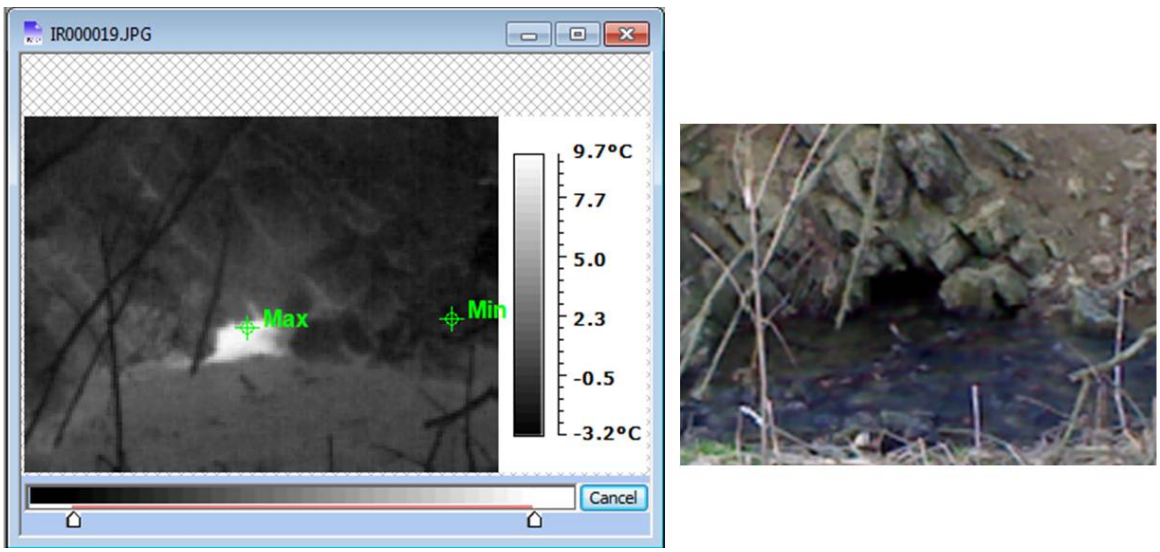

Figure 4: Small spring at base of hill where cave was suspected to be.

location is in a farmer's field on a small knob bisected by a stream. The field had a winter crop of radish and sweet grass with leftover corn stubble from the previous fall. The farmer uses a no-till method of planting, but has only done that for the past couple of years with normal planting procedures used prior to that. The hill is terraced to minimize runoff and erosion and has been farmed that way for the past 20 years. We started by going down to the stream and calibrating the unit on a known spring at stream level (Figure 4). It was quite evident in the camera display that the water coming out of the 20 cm high, 30 cm wide opening in the limestone bank was warmer than both the surrounding rock and the water in the stream (11°C [54° F] versus 0°C [32° F] for the running water and -3.5°C [25° F] for the rock). Both the color palette and temperature range of the RAZ-IR are customizable, but the unit has an auto function as well that will calibrate to the minimum and maximum temperature range in the field of view (FOV). This feature makes the warmest temperatures stand out brightly against the cooler background features, which would make any rocks or soil heated by escaping cave air visible in the color LCD monitor. With verification that the hill was cavernous and blowing air, we started traversing the field with high hopes of finding the buried opening rather quickly. We used a raster pattern, beginning close to the stream bank and working our way uphill in five meter increments. After two hours, the sun had risen high enough in the sky to burn off the morning fog and heat up the land surface enough to make the contrast between the surface temperature and any cave air heated rock indistinguishable. We were done for the day, but undeterred. I still wanted to check the area upstream from the spring resurgence thinking that would be a more likely place for a cave. The next morning, day two of the expedition, we were right back at it well before sunrise, traipsing the field looking for any sign there may be a hidden entrance in the field. After finishing our designated search pattern and having a few minutes to spare before the ground warmed up too much to preclude further searching, we took a quick look at the stream bank with the RAZ-IR and almost immediately spotted a very warm area about the same size as the spring exit, but 50 or so meters upstream and 3 meters higher, the RAZ-IR read a temperature of 11°C (54° F). We went over to check it out and found a depression with lots of brush covering it. As I moved the RAZ-IR closer to get a better idea of where the heat signature was coming from, I got more excited thinking we might have actually found something! I maneuvered the camera into the brush to pinpoint the ”air flow” and then my hopes fell as I noticed a brown furry object four centimeters from the camera lens - we had found a rabbit (Figure 5).

Figure 5: Small rabbit located using the thermal camera.

Our final morning of the expedition was cold, damp and gray. A low pressure system was moving in, giving us hope that we may still find something in the field, so we made our way there through the dark and did several quick sweeps of the most likely areas with

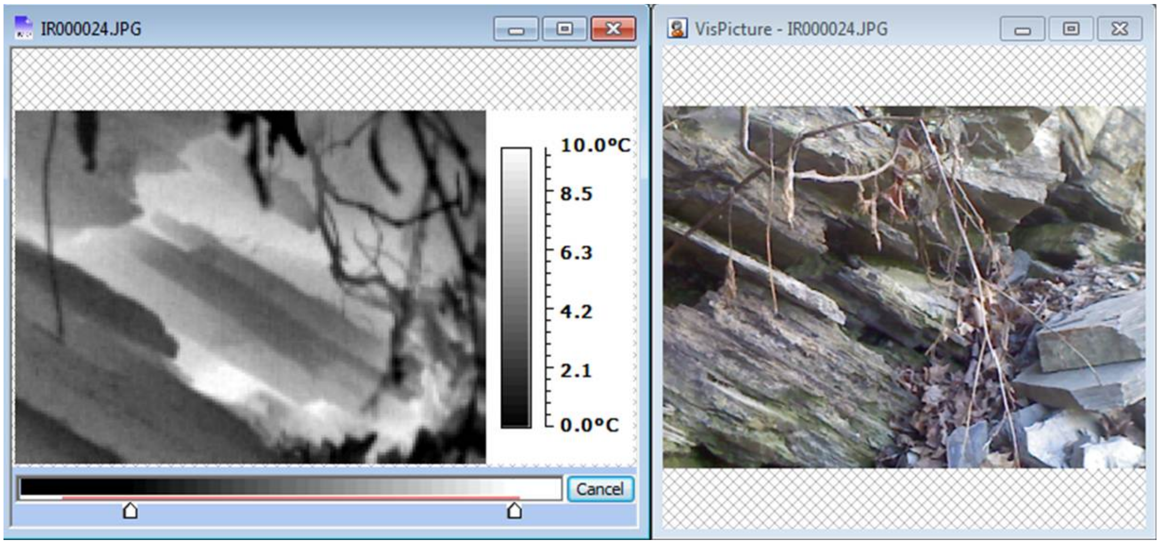

Figure 6: Sinkhole collapse on Martin's Mountain showing heating of the rock by air flowing from a cave.

no luck. We packed up there, said our goodbyes to the farmer and family and hiked over to Martin's Mountain. The cave was rumored to be behind a church, across the stream and up the hill. We traipsed through mud and cow manure, over barbed wire fences and across a frigid stream to get to the purported location, where we found a limestone cliff face with a sinkhole at the base and fresh breakdown just to the north of the sinkhole. We broke out the camera and pointed it toward the base of the cliff and were rewarded with a bloom of thermal energy glowing brightly in our view finder (Figure 6). No air flow was evident except in one place where a spider web was moving slightly. Upon closer visual inspection we could see vapor rising from cracks and crevices at the cliff base. Based on the evidence, we determined this would be a good place for a dig, but weren't prepared for it that day so we moved on. At the top of the cliff we located and imaged two more caves: a six-meter pit with two meter high going leads north and south (Figure 7); and a three-meter pit with a one-meter high going lead toward the south (Figure 8). Of course, being the last day of the expedition we didn't have the time or resources (rope, vertical gear) to check these leads out. We'll have to save the exploration and mapping for another day.

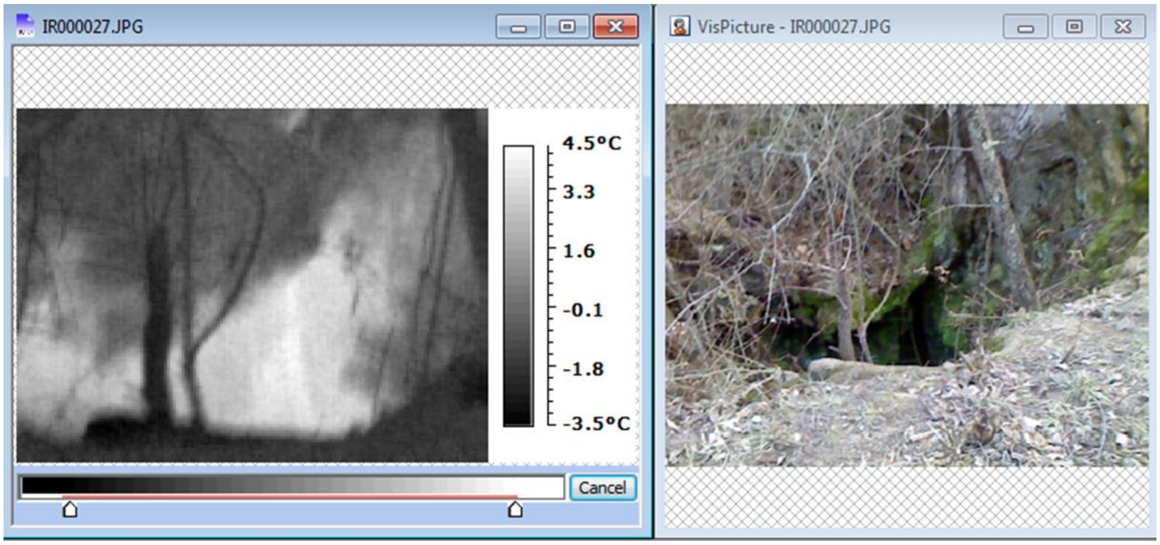

Figure 7: 6 meter deep pit found on Martin's Mountain using RAZ-IR thermal imager.

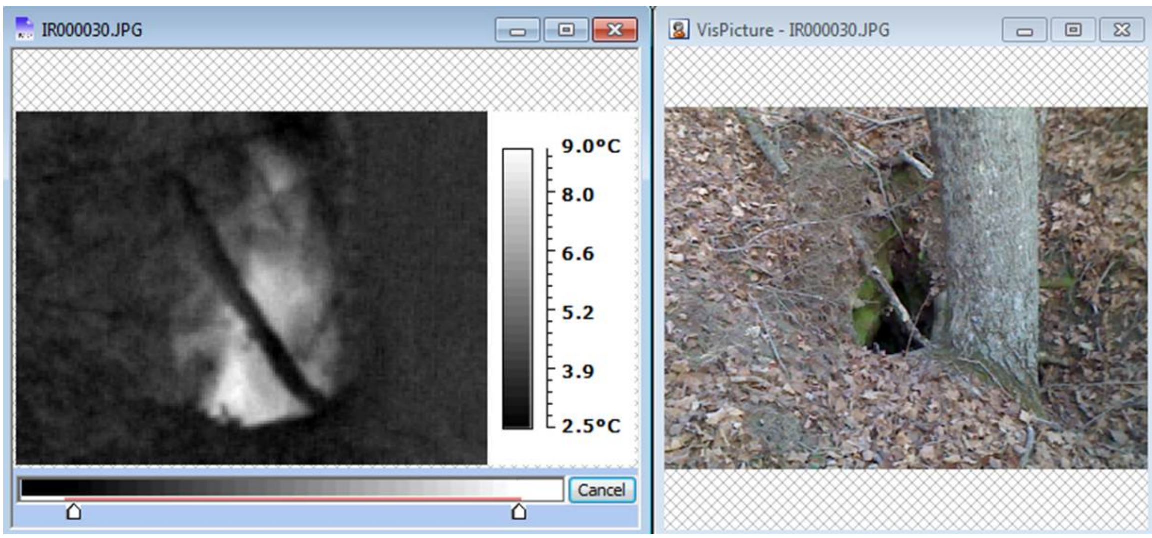

Figure 8: Small swallow hole located on Martin's Mountain using RAZ-IR thermal imager.

The RAZ-IR Thermal Imager worked better than expected in showing thermal differences between cool surface rock and rock heated by air escaping from a cave, even if that cave is blocked by shallow rock fall. The unit itself is very small (6.9 x 4.5 x15.4 cm) and lightweight (350 g including battery) with an integrated, color, high resolution (1600 x 1200 pixels per inch) liquid crystal display (LCD). The temperature detection range is -20° C to 250°C with a 2°C resolution. The camera has a built-in digital camera that takes interleaved infrared (IR) and visual light pictures at 2.0 megapixels, stored as .jpg files on a replaceable 2GB mini-SD card. The files can be viewed with any viewing software, but only the IR image will be displayed unless the analysis software is used.

The camera comes with Guide IrAnalyzer software that automatically de-interleaves the images and displays both the IR and visual image side by side for analysis. Both the camera and the analysis software allow changing the color palette, adjusting the minimum and maximum temperature displayed, and both have the option of pinpointing the maximum and minimum temperature in the FOV. The temperature of any part of the image can be found simply by placing the cursor over that section of the image. The Guide IrAnalyzer software also has the capability to create reports in Microsoft Word and Excel as well as a proprietary customizable format.

In summary, the RAZ-IR worked very well and I was extremely happy with the unit. The RAZ-IR is an excellent tool and does what it is designed to do in a small, compact, rugged package. It has many applications, is user friendly and would make a great addition to almost anybody's toolkit.