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Hot Volcanic Vents on Red Island, Imperial County, California

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Abstract

A survey of Red Island's northern volcanic neck using a thermal imaging camera and infrared thermometer revealed five hot vents. Rock temperatures 1-2 m into the vents were 35° - 38°C (95°-100°F). The vents were found on the south-facing slope at the summit, and were spaced along a ~80 m long line trending N65E. Photos, calibrated thermal images, vent locations and IR imagery of all the Salton Buttes are shown.

1. Introduction

The Salton Buttes are five rhyolitic necks in the Salton Sea Geothermal Field (SSGF) of Imperial County, CA. They lie along a slightly curving, NNE trending line and span a distance of about 7 km. One of them - Red Island - consists of two conjoined volcanoes with related though distinctly different geology. Red Island (also called Red Hill, dating back to before the Salton Sea formed in 1905) is roughly 2.4 km SSW of the Mullet Island fumaroles (Lynch, Hudnut and Adams 2013). The SSGF lies in a tectonic step over region and spreading center between the San Andreas and Imperial faults. The high geothermal gradient results from a shallow magma body and provides the source for geothermal energy plants (Hulen et al. 2002).

Until recently, the Salton Buttes were thought to have formed in the late Pleistocene (~16,000 bp, Muffler and White 1969). More recent work (Lynch et al. 2011, Schmidt et al. 2013) suggests that they could be much younger, with Holocene eruptions as recently 2000 bp. As such, the buttes have come under the purview of the USGS California Volcano Observatory and are now the subject of the CGS mandate to study geologic threats to California.

During the 2008 Desert Symposium field trip (Reynolds, Jefferson & Lynch 2008), Michael McKibben mentioned a volcanic "hotspot" on the southwestern flank of the northern volcano at Red Island (personal communication). A brief search of the area during the field trip did not reveal its location, so we later undertook a systematic search of the buttes. In this paper we report the discovery of five hot vents during a partial survey of Red Island North on November 6, 7 & 29, 2013.

2. Methods

As part of a larger effort to identify the surface thermal morphology of the buttes, we began by searching the southern flank of Red Island's northern volcano, in Red Hill Park, Imperial County. Three search tactics were employed, both during early morning before

sunrise when it was coolest and thermal contrast between cold and hot rocks were highest. 1) Using an Agema ThermoVision 570 infrared camera (wavelengths ~8-13 micrometers), we looked for areas that were warmer than the background, 2) we stuck our hands into holes and crevasses to see if they felt warm, and 3) we remotely measured temperatures of rocks using a Martin P. Jones & Associates, Inc., Model 9910 TE Infrared Thermometer. Owing to systematic effects with the IR camera, absolute temperatures could be off by 3-4°C, although the relative temperatures between different parts of the scene are preserved. IR thermometer temperatures were usually higher than those recorded by the IR camera because the thermometer was smaller and could be placed deeper into the vent.

Once the vents were identified, we inserted a type K thermocouple (with an Omega HH-52 digital thermocouple reader) into the opening - sometimes horizontally as the geometry of the vent dictated - and measured the temperature as a function of depth. Typical insertion distances were about two meters before resistance prevented deeper penetration. In all cases the temperature rose quickly with depth and leveled out around 38°C, often only a half meter into the vent. Thus we were unable to determine the local geothermal gradient.

3. Results on Red Island North

Figure 1 shows a Google Earth image with the locations of the hot vents on Nov 29, 2013. Table 1 lists their locations. Thermal IR (TIR) images and corresponding visible photographs for vent H4 are shown in Figures 2. Figure 3 shows visible and TIR pairs for H1 and H3. All vents were emitting hot moist air that condensed to form a cloud, and the surrounding rocks were wet due to condensation of emitted water vapor. Except for water and greenish algae, no other surface deposits (e.g. sulfur) were seen. Bees were seen flying in and out of several vents. The vents were found on a south-facing slope at the summit. They were distributed along a ~80 m long line trending N65E, a possible fault. Within this and the area extending 225 m to the south and west, we are reasonably confident that there are no additional hot vents.

Table 1

Name	WGS84 Latitude	WGS84 Longitude
H1	33.19977	-115.61249
H2	33.19986	-115.61206
H3	33.20004	-115.61172
H4	33.19981	-115.61211
H5	33.19985	-115.61222

Even from relatively nearby - a few meters - the vents appeared unremarkable among the uneven field of loose, jutting volcanic rocks. One was found by feeling hot air coming from it, two were located with the IR camera, one was identified by noticing wet rock, and one was found by seeing a small cloud emanating from it. The clouds form when warm humid air coming from the vent mixes with cold ambient air and condenses. After locating the vents and viewing them in the direction of the low sun, the location of each was found to be readily visible by forward scattering of sunlight from their cloud's water droplets (Figure 4).

Figure 1. Google Earth image of the vent area with locations marked. The line of vegetation is the result of water flushed from the tank.

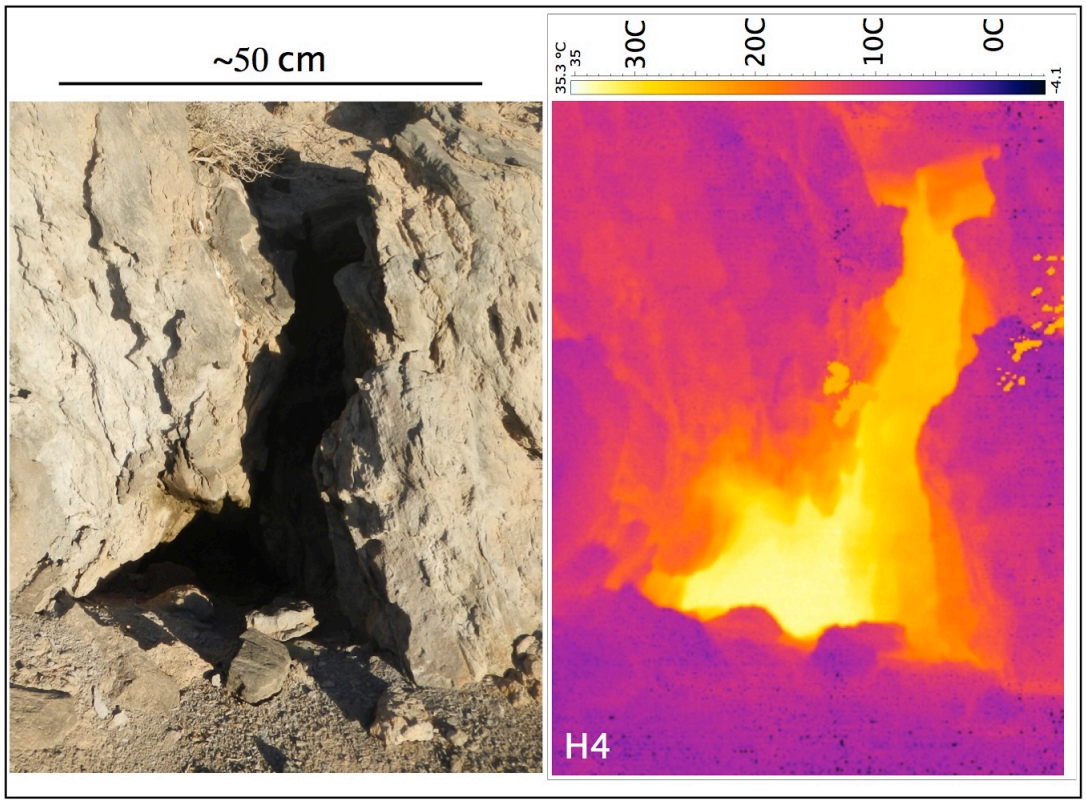

Figure 2. H4. Left: visible, Right: thermal infrared. Bad pixels in the IR camera are obvious as sharp yellow patches at center and center right.

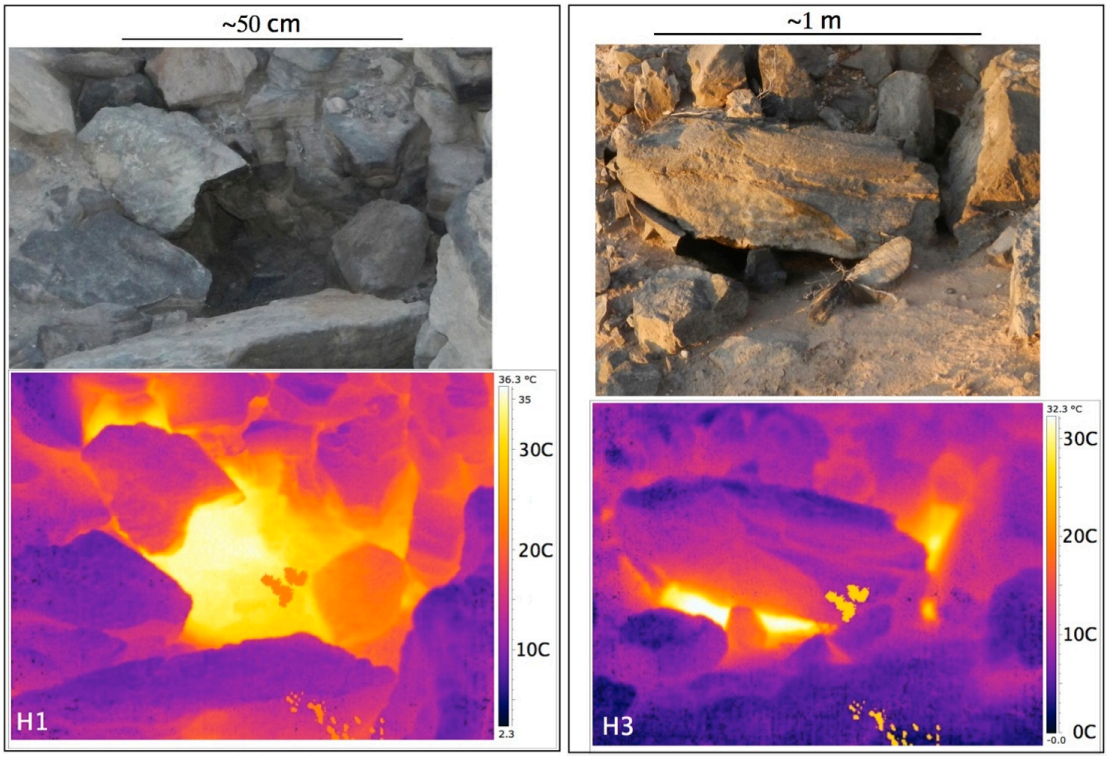

Figure 3. Top: visible, Bottom: thermal infrared.

Figure 4. Single frame from a video showing the emerging cloud from H1.

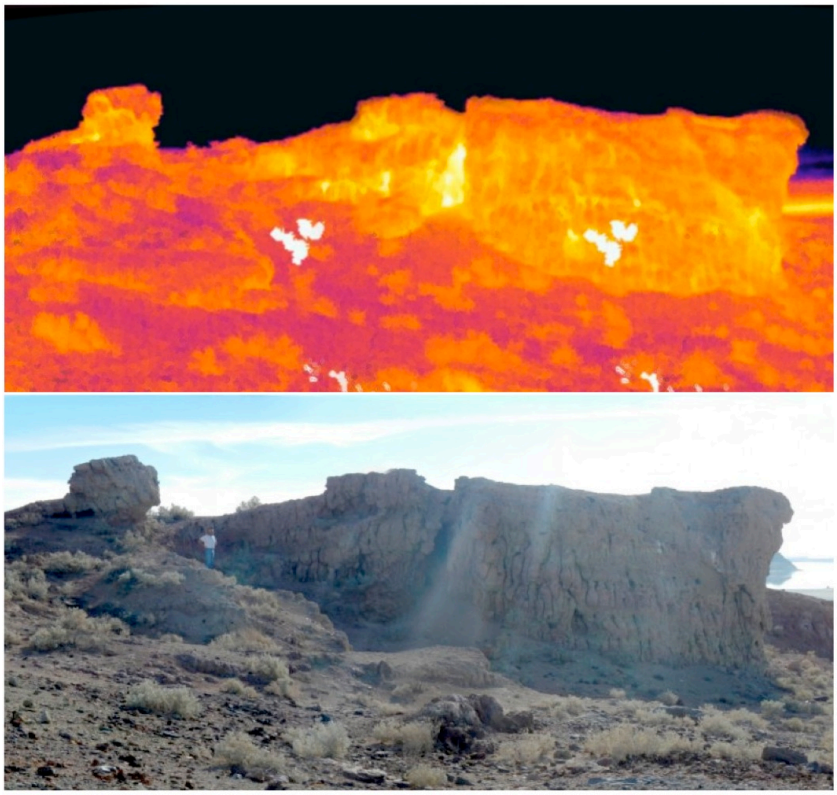

Figure 5. Thermal infrared panorama (top) and visible panorama (bottom) from the thermal survey. Shown here is a north-facing wall on Red Island South. Note bright (warm) crevasses near the center of the upper TIR image. White areas are bad pixels in the TIR camera. There is man standing in the lower image for scale.

4. Thermal Infrared Survey of the Buttes.

On Jan 18-19, 2014, we did a complete imaging survey of all the five buttes. During the day we took visible images in groups at many points, and marked each location using a handheld GPS receiver. After midnight we obtained thermal IR imagery from the same locations as the daytime photos. Images were digitally stitched together (Figure 5) and the images were registered using image-warping software. Hundreds of "warm spots" were found, that upon closer examination on foot with better spatial resolution might turn out to be volcanic vents. The approach is to use the TIR images to guide us to hot spot locations, using the visible images as references. This is an ongoing project.

5. Comments

In view of McKibben's information (Section 1), it seems that at least one of these vents was known to local people and perhaps to visitors to Red Hill Park. While the vents were not marked, one of them (H3) looked as though someone may have piled rocks around it.

The Red Island hotspots could represent heat from the original volcanism, or recent magma intrusions that have not reached the surface. All are at the summit of Red Island (north volcano), where one might in general expect magma to appear at the surface (as opposed to a flank).

We believe that the source of the heat in the hot vents is volcanic in origin. We further speculate that the vents are only the surface manifestation of much deeper openings into the volcano. Although we found many openings that were superficially similar to those of the hot spots, none were hot and none had water vapor emission. The origin of the water vapor that is being emitted is unknown, but is almost certainly water from the Salton Sea, which lies 95 ft. lower. Whether this water is found higher in the volcano – a water table of sorts – is not known.

It is worth noting that there is a water tank very close to the vents. One might worry that perhaps water is leaking from it and providing the source of water. We view this as improbable, and in any event does not explain the heat source.

With air temperatures around 8°C (46°F) during our study, it seems unlikely that warm air coming from the vents could have been felt on a hot and/or windy day. It also seems unlikely that TIR images would reveal the vents on hot days; so working on cold nights seems to be the optimum approach. Indeed, daytime TIR images were dominated by warm, sunlit surfaces.

Much of the surface of Red Island North and Obsidian Butte have been bulldozed, quarried or otherwise man-modified. Such activity would fill in vents and heat diffusion to the surface, thereby suppressing thermal signals. Deeper cuts might expose warmer interior temperatures.

Many "warm" spots were also found on the largely undisturbed, southwest flank Red Island's northern volcano. These were places that the IR camera found to be roughly 5°-10°C (9 – 18° F) warmer than ambient. Such warm spots may represent weak signals from the warm interior of the volcano. We believe, however, that most of them were due to emissivity variations in the rocks layers, or normal temperature distributions that occur in crevasses where the rock is not able to radiate its heat to the cold night sky. None of these "warm" spots was associated with a vent or outgassing.

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