Remote Sensing of Geothermal Activity and Gaseous Emissions Along the Calipatria Fault in the Salton Sea Geothermal Field, Imperial County, California

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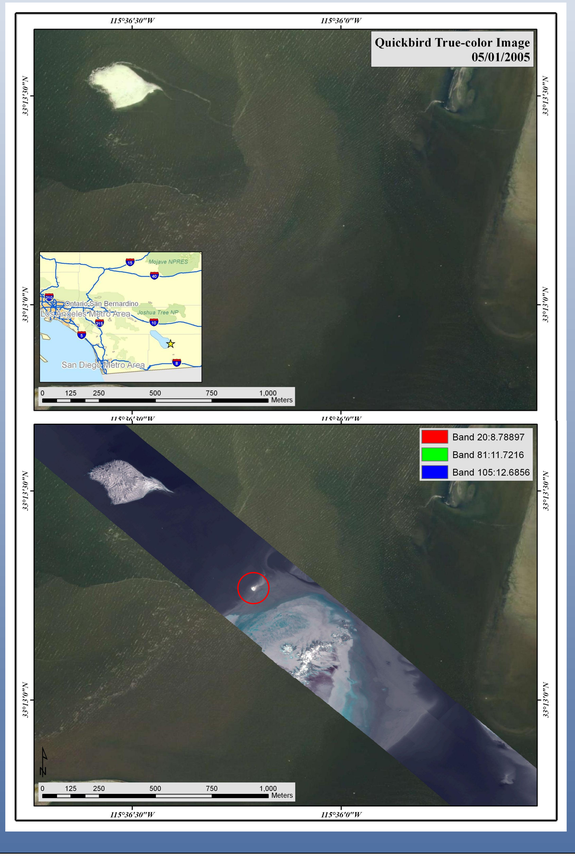
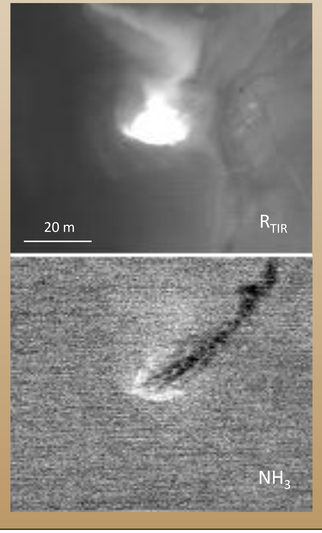
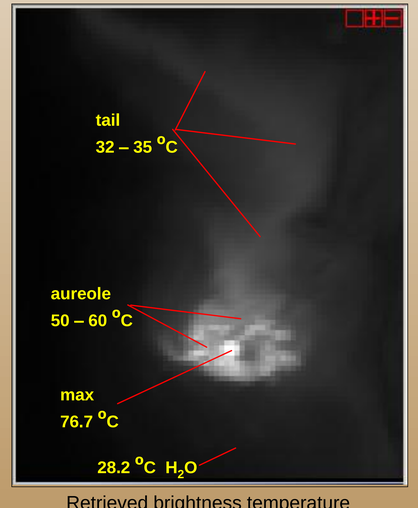
An airborne hyperspectral imaging survey was conducted along the Calipatria Fault in the vicinity of the Salton Sea in Southern California. The imagery was acquired at ~0.05-μm spectral resolution across the 7.6–13.5 micron thermal-infrared spectral region with a ground sample distance of approximately 1 meter using the SEBASS (Spatially Enhanced Broadband Array Spectrograph System) sensor [Hackwell *et al.*, 1996]. In addition to strong thermal hot spots associated with active fumaroles along the fault, a number of discrete and distributed sources of ammonia were detected in this manner. In particular, Mullet Island, some recently exposed areas of sea floor, and a shallow-water fumarolic geothermal vent all indicated ammonia emissions, presumably originating from decomposition of agricultural runoff and the decay of algae in the sea bottom sediments [Holdren and Montaño, 2002; Miller *et al.*, 2005]. The techniques developed during this field experiment suggest a potential methodology for monitoring certain of the toxic episodes that are a known source of mass aquatic fauna kills within the Salton Sea ecosystem. Hyperspectral surveys such as this have shown value for a variety of geological explorations and monitoring programs.



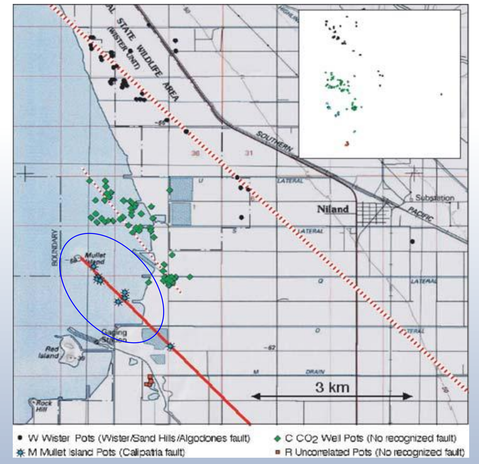
Crustal thinning and associated upward magma migration within the Salton Trough have resulted in local hotspots whose surface expression is characterized by minor volcanic features such as fumaroles and mud pots. The Mullet Island/Calipatria Fault complex is associated with the Mullet Island Thermal Anomaly [Sturz, 1989] and was chosen as a principal target for this collection campaign. A set of NW/SE aligned flightlines was laid out along the presumed track of the Calipatria Fault to include Mullet Island and known surface vent features, which have recently been identified and mapped in detail [Svensen *et al.*, 2007; Lynch and Hudnut, 2008]. The data collection was carried out during the interval 19:43–20:21 UTC on March 26, 2009.

The most distinctive feature of this data collection is the large number of ammonia (NH_3) detections it contains (far right, below). Several NH_3 plumes were observed to emanate from Mullet Island and the offshore sand bar that was overflown (see flight track overlay on visual scene depicted above). However, the strongest ammonia signature was obtained from a thermal hotspot located in shallow water near the sand bar. The location of this feature is marked by the red circle in the visual context image above and in the overhead infrared imagery at left. The detailed thermal structure of the feature itself is highlighted below. This hotspot is due to the presence of a geothermal vent at that location, one of several mapped recently [Lynch and Hudnut, 2008].



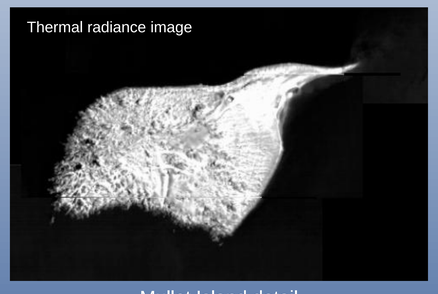


Retrieved brightness temperature

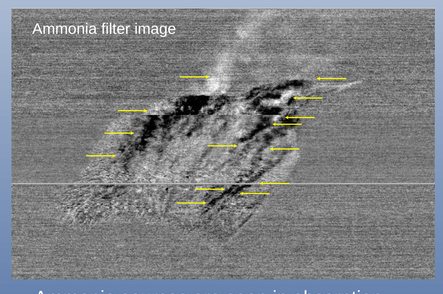


- The solid red line at the lower left delineates the assumed surface outcropping of the Calipatria Fault, which is also inferred to pass through Mullet Island.
- Also shown are the locations of known mud pots and vents occurring in association with the fault.
- The blue ellipse denotes the section of the fault that was flown for the current study.

(Adapted from Lynch and Hudnut, 2008)



Mullet Island detail



Ammonia sources are seen in absorption over the warm island terrain and in emission over the cooler lake waters.

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