FLIR APPLICATION STORY

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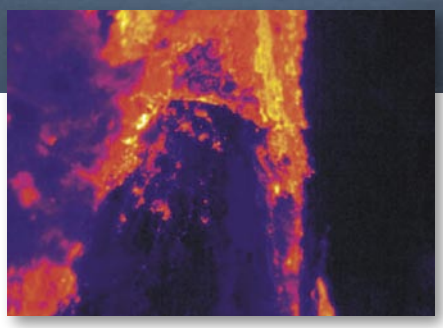
Stromboli: the 5 April 2003 eruption, a few seconds after the main blast

Under the Volcano: FLIR Systems cameras used to monitor active volcanoes

If an infrared camera is the instrument to detect and measure hot spots, it must be the perfect tool to survey the biggest and most impressive hot spots on earth: volcanoes.

Italy is home to at least two of the world's currently most active volcanoes. Its Istituto Nazionale di Geofisica e Vulcanologia (INGV) and in particular, the institute's branch based in the city of Catania, Sicily, (INGV-CT) oversees the notorious Mount Etna and Stromboli volcanoes as well as the somewhat less smoking and bubbling Aeolian Islands. The Institute's consistent use of thermal imaging and hence its cooperation with FLIR Systems started 2001.

"Infrared monitoring of volcanoes gives new insights into the complex mechanisms which control the volcanic system", says Dr. Sonia Calvari, Volcanology Unit Manager at the Catania branch: "they help to measure and map active lava flows, to detect new cracks and landslide scars, to monitor the crater's inner morphology and temperature, and to gather the change patterns which usually precede eruptions."



Visual and thermal image of hot cracks developing along the Sciara del Fuoco hillside, about one hour before flank failure and tsunami.

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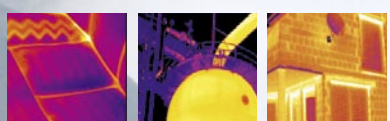


How to collect volcano imaging : parameters

During the 2002–2003 eruption of the Stromboli volcano, Calvari and her team conducted daily monitoring with the infrared camera from a helicopter hovering above the crater and offshore, and from vantage points overlooking the flow fields.
They gathered a huge amount of airborne and ground-based thermal data before, during and after the eruptive event. The survey team used a ThermaCAM P695, a predecessor of the current FLIR Systems P-series professional camera range, with a 320 x 240 pixel FPA, a standard 24 x 18 lens and calibrated to reach a maximum measurement temperature of 1,500°C. This high temperature was needed to image particularly active lava flows at close range.

Flights were done in the early morning to avoid solar reflection and direct sunlight.
Ambient temperature and air humidity were measured every time at the start of the thermal survey at appropriate elevations. Selecting a temperature range appropriate to the targeted feature and the line-of-sight distance proved to be important. Moreover, a careful balance was necessary to be able to detect low temperature anomalies while avoiding image saturation over higher temperature features.
Also, gathering temperature evidence in volcanic areas is hampered by some typical factors: while basaltic lavas have a high and relatively stable emissivity from 0.95 to 0.98, the infrared images have an estimated 5% distortion caused by the uneven topography of the site, even when using modern geo-technological surveying tools.
In addition, crater surveying data are strongly affected by high concentrations of SO2 (sulfur dioxide) present in the heavy gas emissions from the volcano. Errors on these images can vary from 10 to 20%.

Applications, results, benefits

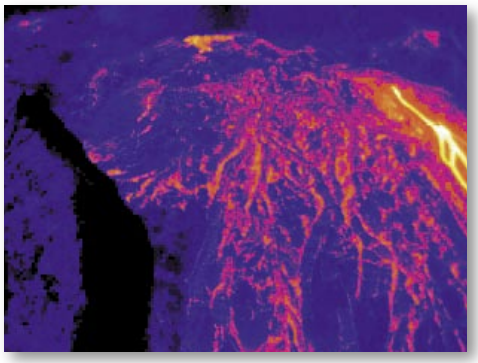
The Catania branch researchers obtained excellent results during the Mt Etna and Stromboli eruptions of 2002 and 2003: thermal surveying detected the opening of fractures along the Sciara del Fuoco (the hill side from which lava and deposits roll to the sea) one hour before the outburst that caused severe destructions in one of the Stromboli island's two villages on December 30, 2002. The survey team has collected and analyzed a total of 100,000 infrared images. Together with visual observations, seismic, gas geochemistry and ground deformation data, the imagery allowed them to reconstruct a detailed chronology of the eruptive events. "And, "says Sonia Calvari, "our survey provided a powerful demonstration of the capabilities of, portable, easy-to-use handheld infrared cameras to track and register complex volcanic processes and look through the curtain of smoke and gases."

Towards permanent thermal monitoring

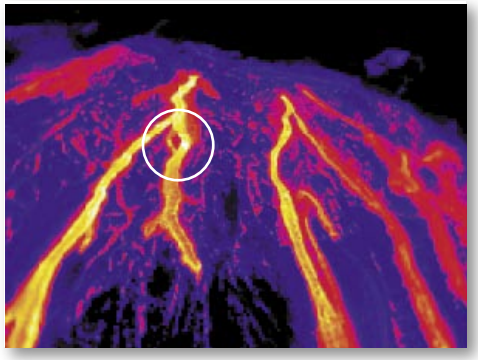
Now, the Catania institute is setting up permanent infrared camera monitoring at major volcanic sites in its region. FLIR Systems ThermoVision A40-M fix-mounted cameras are installed near the Etna and Stromboli craters. They provide data which enable to define threshold values that can be used as a warning system for volcano explosions.

The Institute uses a FLIR Systems S65 handheld camera during monthly low-level flights over Vulcano, another tiny, touristical and volcanically active island to the north of Sicily. In addition, the Institute's surveyors will soon install one ThermaCAM S65 and two ThermoVision A40-M on a permanent basis to continuously observe the fumaroles fields inside craters on the island. Fumaroles are holes from which hot gases and vapors issue. The camera's should be placed at a distance of 50, 100, 400 m respectively from the fumarole's field to avoid atmospheric distortions caused by the hot sulfur dioxide holes. The image data will be used to make histograms to compare various fumaroles areas and to monitor internal changes as well as external, seasonal effects on the fumaroles.
"Says Calvari: The last eruption on Vulcano took place from 1888 to 1890, and we're sure a next one will come, the question is only to know when…"

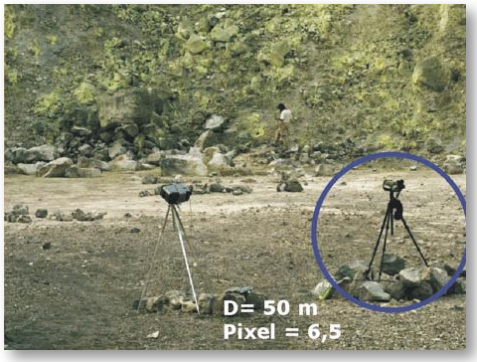
Acknowledgements to Francesco Biasciano, Area Sales Manager, FLIR Systems Italy, for providing contacts and support.



Stromboli: cracks opened along the upper lava flow field. Active lava flows are yellow, cracks are red.



Opening of a vent in the middle of the flow field.



FLIR Systems cameras located located along a NE-SW trending line, Vulcano Fossa fumarole field, Vulcano Island.

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