

APRIL 2009 FERNANDINA VOLCANO ERUPTION, GALAPAGOS ISLANDS, ECUADOR: THERMAL MAPPING OF THE LAVA FLOWS EMITTED



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INTRODUCTION

Fernandina, the westernmost volcano of the Galapagos Archipelago, erupted in early April 2009, satellite data suggested that the eruption began sometime between 22:00Z on 10 April and 00:30Z on 11 April. Based on the information from the seismic station at Santa Cruz Island, no earthquakes were associated with this eruption. Fernandina Island is about 32 km in diameter, a maximum elevation of 1470 m with a central caldera (Fig. 1b). Fernandina volcano is among the most active in Galapagos; at least 21 eruptions have been reported since 1813 (Smithsonian Institution - GVN, 2011). The eruption of 1968 was followed by the largest historical caldera collapse on any basaltic volcano, with a maximum subsidence of about 300m [Simkin and Howard, 1970].

Recent activity at Fernandina includes intracaldera and fissure flank eruptions in 1991, 1995 and 2005.

A field campaign was conducted by IG-EPN from 27 April to 5 May 2009 with the support of NOVAC project and the logistics supplied by the Galapagos National Park Service (GNPS), the purpose of this campaign was to obtain SO₂ and infrared thermal data by field measurements on a basaltic eruption and to compare the results with satellite data. Thermal images obtained during the field campaign have been used to map the recent lava flows and deposits.

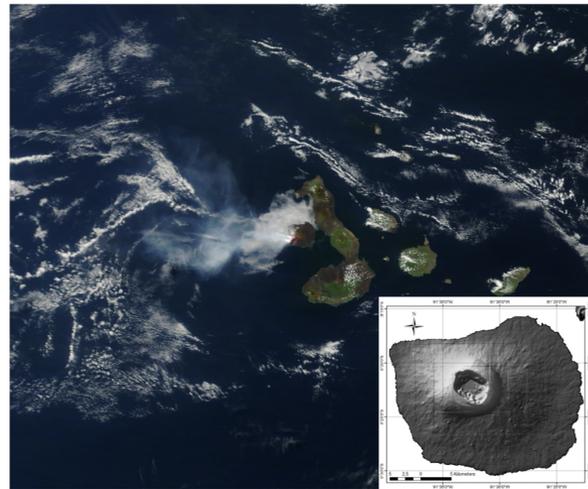


Figure 1: A) MODIS image of Galapagos, 11 April 2009. The eruption plume extends from the volcano more than 100 km to the W. Hot spots detected by HIGP are also shown. **B)** DEM of Fernandina Island (provided by IG).

ERUPTION CHRONOLOGY

10 APRIL: Satellite images from HIGP (hot spots) suggest that the eruption began sometime between 22:00Z on 10 April and 00:30Z on 11 April.

11 APRIL: First eyewitnesses, a tourist boat and Galapagos National Park rangers located on Canal Bolívar, report an eruptive column on the morning of 11 April. A MODIS satellite image taken on the morning of 11 April showed a steam plume rising from the SW flanks (Fig. 1A).

After a flight made in the afternoon by SPNG personnel it was confirmed that the eruption was located in the SW flank of the volcano along a radial fissure (Fig. 2) and that lava flows had traveled several kilometers downslope finally reaching the ocean.

According to the records from the seismic station at Santa Cruz Island, no earthquakes were associated with this eruption. An Special Report issued by IG was sent to the authorities and the media with updates of the recent activity.

12 APRIL: GNPS Officers conducted another flyover on 13 April 2009 and found the eruption's intensity similar to the previous day. The eruption source was a radial fissure on the SW flank, in an area ~ 500 m from the summit crater near the site of the 2005 eruption. The fissure was ~ 200 m long and 10 m wide, and ejected lava fountains 15 m high (Fig. 3).

14 APRIL: OMI satellite images show important degassing from April 11th to April 16th, with the higher SO₂ picks on April 12 and 14. This degassing is associated with ash emission observed with MODIS satellite (Fig. 1A, 4).

15 APRIL: During a flyover on the morning of 15 April, personnel from the GNPS verified that the eruption continued, but with lower intensity than in the days before. Three vents at ~ 400 m elevation on the southwest flank along the radial fissure were active, feeding a lava flow up to 10 m wide.

16 APRIL: Gas-and-steam plumes from Fernandina drifted up to 555 km W. GNPS Rangers observed activity at the upper vents and lava flowing into the ocean (Fig. 5).

17 APRIL: Satellite images recorded by OMI show a drastic decrease of activity after 16 April and a new increase on 23 April. This decrease in the activity intensity is confirmed by a lower number of thermal alerts reported by MODIS satellite.

29 APRIL: IG team arrives to Fernandina, they observe only incandescence in the upper vents zone, gas emission from the vents and steam coming out from the lava flows. The eruption had finished.

30 APRIL: IG geologists made thermal images of the vents and lava flows, measured SO₂ concentrations and took ash and rock samples close to the main vents.

Satellite images taken by the OMI instrument for 30 April 2009 shows very low concentrations of SO₂, hundreds of km W of Fernandina Island.



Figure 2: Aerial photograph taken 11 April 2009 of the eruptive fissure (Courtesy of Oscar Carvajal, GNPS)



Figure 3: Aerial photograph taken 12 April, the fissure was ~ 200 m long and 10 m wide, and ejected lava fountains 15 m high (Courtesy of Oscar Carvajal, GNPS)

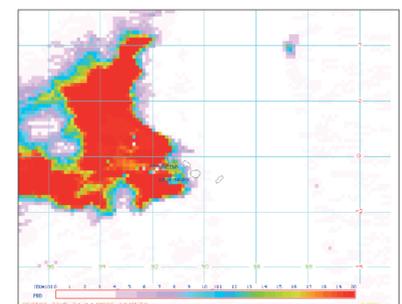


Figure 4: OMI Satellite image for 14 April 2009, showing an important SO₂ emission moving hundreds of km to the NW and to the W



Figure 5: Photograph taken early in the morning of 16 April from a boat sailing close to P. Hammond (Courtesy of Juan García, GNPS).

FIELD OBSERVATIONS

Figure 6 is a satellite image after the April 2009 Fernandina eruption identifying individual lava flows and other points of interest observed during the field recognition:

- 1995 eruption upper vents with the associated lava flows.
- 2005 eruption upper vents with the associated lava flows.
- 2009 eruption upper vents (~550 m) covering part of the 1995 eruptive fissure and lava flows. These vents displayed important activity during the first overflight (13 April); Maximum Apparent Temperature (MAT) measured with the thermal camera was 179 °C.
- 2009 eruption (Radial Fissure/RF) upper vents (~700 m) located W of 1995 eruptive fissure; vents active during the first flight (13 April); MAT measured with the thermal camera was 67 °C.
- Dark grey patch not observed on images previous to April 2009 eruption; might correspond to a short-life vent with small lavas.

6. 2009 eruption (RF) principal vents elevation of ~500 m; last visual observation of incandescence was on 29 April; measurements with a thermocouple in a 50 cm large and greater-than 30 m-long crack gave maximum temperature of 970 °C.

7. Area covered by the principal April 2009 lava flows that reached the sea; MAT measured with the thermal camera was 131 °C.

8. 1995 eruption (RF) principal vent; during the first part of 2009 eruption, the lava flowed W to this vent and reached the ocean, a different lava lobe flowed to the E but never reached the ocean.

9. The SE lobe of the 2009 lava flow borders the 1995 lava field and ends 1800 m before entering into the ocean; MAT measured with the thermal camera was 70 °C.

10. The April 2009 lava flows entered into the ocean the first days of the eruption; this region of the lava flows is 800 m-wide; MAT measured with the thermal camera was 132 °C.

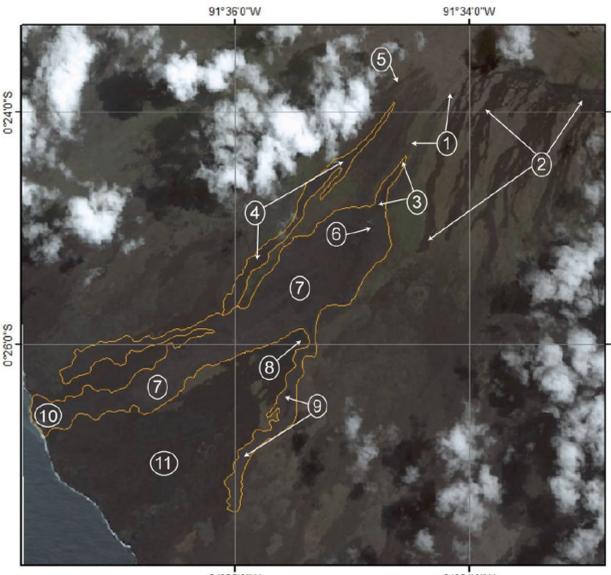


Figure 6: Satellite image after the April 2009 Fernandina volcano eruption with the area covered by the new products.



Figure 7: Photograph of the area where the main vents were located at an elevation of ~500 m, taken on 1 May, a few days after the end of the eruption.

RESULTS AND CONCLUSIONS

Thanks to the strong thermal contrast between the new products and the older lava flows, it was possible to map precisely the limits of April 2009 eruption (Fig. 8). The thermal contrast information has been stacked on satellite images and the area has been calculated with the help of a DEM.

The area covered by the April 2009 eruption is of about 6.7 km² which is a value similar to the 1995 eruption (6.5 km²; Rowland et al., 2003). Considering the similarities between both eruptions, we used the average thickness calculated by Rowland et al. (2003) for the 1995 eruption (14 m), to estimate the 2009 eruption volume. It gives an approximate volume of 94*10⁶ m³ of lava emitted.

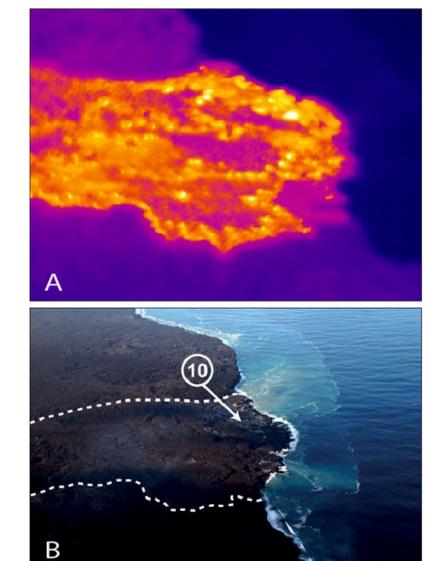
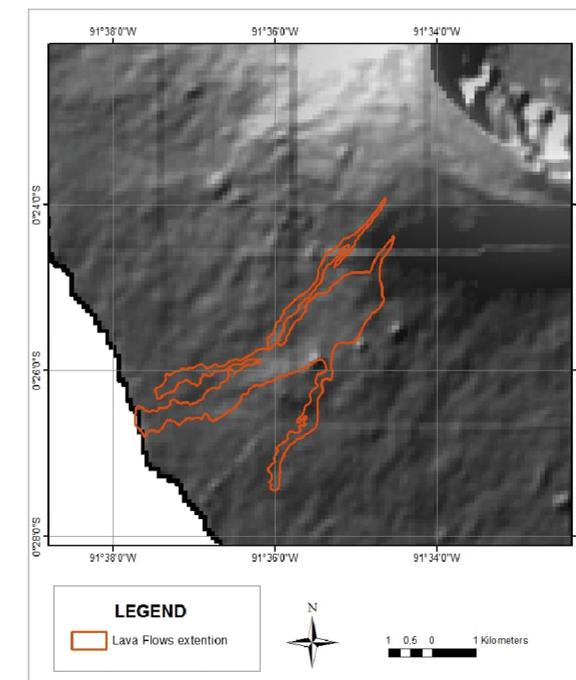


Figure 8: Thermal image (A) and photograph (B) of SW lava flow (10) of April 2009 eruption entering into the ocean eruption, numbers refer to Fig. 6.

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