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The 2011 El Hierro submarine eruption: estimation of erupted lava flow volume on the basis of helicopter thermal surveys

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El Hierro represents the summit of a volcanic shield elevating from the surrounding seafloor at depth of 4000 m to up to 1501 m above sea level. The island is believed to be near the present hotspot location in the Canaries with the oldest subaerial rocks dated at 1.12 Ma. The subaerial parts of the El Hierro rift zones (NE, NW and S Ridges) are characterized by tightly aligned dyke complexes with clusters of cinder cones as their surface expressions. Since 16 July, an anomalous seismicity at El Hierro Island was recorded by IGN seismic network. After the occurrence of more than 10,000 seismic events, volcanic tremor started at 05:15 on 10 October, followed on the afternoon of 12 October by a green discolouration of seawater, strong bubbling and degassing, and abundant bombs on a decimetre scale found floating on the ocean surface offshore, southwest of La Restinga village. The Canary Government raised the alert level from green to yellow on 10 October (3 colour basis: green, yellow, and red). Further episodes have occurred during November, December 2011 and January 2012, with turbulent water, foam rings, and volcanic material again reaching the sea surface. Colour of the discoloured area has changed frequently from light green to dark brown, depending on the eruptive activity. During the whole eruptive period, The Volcanological Institute of Canary Islands and the Helicopter Unit of the Spanish Civil Guard have carried out regularly thermal surveys with a hand held FLIR Thermal Camera P65. The images have been collected taking care of avoiding solar reflection (with cloudy weather) or at times of the day without direct sun light. Air temperature and humidity were measured with a handled thermo-hygrometer every time before the thermal image collection, and measurements were always performed at two fixed heights: 2000 and 1000 feet, and images were collected as perpendicular as possible to the surface. Together with thermal images, digital photos of the surface have been collected each time in order to compare the temperature distribution with the features observed on the sea surface. Calculation of lava flow volume and effusion rate from thermal images collected by helicopter surveys has been largely used during the last decade for monitoring effusive eruptions at Etna, Stromboli, Kilauea, and other volcanoes. In this study, lava flow volume is calculated on the basis of temperature difference between the seawater contained within the dark patch, and the temperature of the seawater surface away from the eruption. These values have to be considered as minimum values, because they do not take into account the volume of lava isolated from the seawater by a thick crust that did not contribute to seawater warming. To calculate the lava volume we have used the model proposed by Harris et al. (1998) for the portion of the lava flow field spreading below sea level. Preliminary results indicate that during the period of study, about 5Mm3 of magma have been needed to heat the observed surface heated sea water at the submarine eruption site.