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Cotopaxi volcano's unrest and eruptive activity in 2015: mild awakening after 73 years of quiescence

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Cotopaxi volcano (5,897 m) is located 50 km south of Quito, the capital of Ecuador. The most dangerous hazards of this volcano are the devastating lahars that can be generated by the melting of its ice cap during pyroclastic flow-forming eruptions. The first seismic station was installed in 1976. Cotopaxi has been monitored by the Instituto Geofísico (Escuela Politécnica Nacional) since 1983. Presently the monitoring network is comprised of 11 broadband and 5 short period seismometers, 4 scanning DOAS, 1 infrared and 5 visible cameras, 7 DGPS, 5 tiltmeters, 11 AFM (lahar detectors) and a network of ashmeters. Due to the recent unrest, the monitoring of the volcano has been complemented by campaign airborne Multi-GAS and thermal IR measurements and ground-based mobile DOAS and stationary solar FTIR.

After 73 years of quiescence, the first sign of unrest was a progressive increase in the amplitude of transient seismic events in April 2015. Since May 20, an increase in SO_2 emissions from ~500 t/d to ~3 kt/day was detected followed by the appearance of seismic tremor on June 4. Both SO_2 emissions of up to 5 kt/day and seismic tremor were observed until August 14 when a swarm of volcano-tectonic earthquakes preceded the first phreatic explosions. These explosions produced ash and gas columns reaching up to 9 km above the crater. The ash fall produced by the opening phase covered over 500 km^2 with a submillimetric deposit corresponding to a mass of 1.65E+8 kg (VEI 1). During this period of explosions, SO_2 emission rates up to 24 kt/day were observed, the highest thus far. The ash was dominantly hydrothermally altered and oxidized lithic fragments, hydrothermal minerals (alunite, gypsum), free crystals of plagioclase and pyroxenes, and little juvenile material.

Unrest continued after August 14, with three episodes of ash emission. However, the intensity of ash fallout, average seismic amplitude, and SO_2 emissions during each successive episode progressively decreased, while juvenile component increased. Total ash fallout mass since August 14 yield 1.19E+9 kg. During these episodes BrO and HCl were detected in the plume, and airborne Multi-GAS measurements showed that the plume had a CO_2/SO_2 ratio from 1 to 2.5 and that SO_2 was >99% of total sulfur (SO_2+ H_2S), indicating a shallow magmatic origin for the gas. During ash emissions temperatures of up to 200º C were measured at the column with an IR camera. Thermal anomalies in the upper part of the edifice have also been observed and have resulted in minor melting of the ice cap. This phenomenon has produced small secondary lahars with a maximum discharge on the order of 10 to 30 m^3/s.

Since late November 2015, surface manifestations and the other monitored parameters have shown a marked decrease. Historical reports of Cotopaxi's activity show that both short and long-lasting eruptive periods usually start with mild eruptive phases prior to culminating in VEI 3 or 4 eruptions. Therefore special care should be taken in monitoring unrest at Cotopaxi in order to identify precursory signs of a larger eruption.