Nat. Hazards Earth Syst. Sci. Discuss., 3, C2958–C2961, 2016
www.nat-hazards-earth-syst-sci-discuss.net/3/C2958/2016/

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Evaluation of the initial stage of the reactivated Cotopaxi volcano – analysis of the first ejected fine-grained material" *by* T. Toulkeridis et al.

B. Bernard

bbernard@igepn.edu.ec

Received and published: 12 January 2016

After reading this manuscript I agree with all of the comments posted by the two anonymous reviewers but I feel that some other major issues should be raised.

1) Sampling: the reviewer 2 exposes major flaws in the methodology used to analyse the ash samples but there are also problems with the sampling methodology itself. Most of the sampling sites presented in Figure 2 are not located along the main axis of dispersion of the ash plume (NW) during the August 14 eruption. On that day the ash fallout in Lasso (WSW), Amaguaña (NNW) and Sangolqui (N) were very small (<50 g m-2). A fallout map of this eruptive event is available following

this link: http://www.igepn.edu.ec/cotopaxi/informes-cotopaxi/coto-especiales/coto-e-2015/13327-informe-especial-cotopaxi-21-08-2015/file

Furthermore the towns Machachi (NW) and Lasso (WSW) are not located along the main axis of dispersion of the ash plume over the following weeks where ash plumes concentrated to the W and WNW:

http://www.igepn.edu.ec/cotopaxi/informes-cotopaxi/coto-especiales/coto-e-2015/13527-informe-especial-no-12/file

http://www.igepn.edu.ec/cotopaxi/informes-cotopaxi/coto-especiales/coto-e-2015/13528-informe-especial-no-13/file

It is well established that collecting ash for componentry analysis far away from the volcano and on the edge of the plume is controversial due to potentially large effects of density segregation. A proper sampling and analysis strategy is provided in Eychenne and Le Pennec (2012). Also, after the main event, Machachi area was mostly affected by wind reworking of the first fallout and therefore any sample from this area after the 14th should not be considered as pure enough for further analysis.

The authors state that "The sites of the collection were chosen to be implemented in areas with the highest probability of ash precipitation as known by the evaluation of the wind directions of ash-charged clouds for the years 1999 up to 2015" which is W, but none of the sample sites are actually in that direction.

No information is given on the thickness or the load of the deposits corresponding to the samples even though this is basic information.

2) Main event: as an introduction to the main event the authors present some warnings missed by the IG-EPN towards authorities/public using 5 different eruptions. Two of them occured in remote volcanoes (Sierra Negra and Wolf, Isabela Island, Galápagos Archipelago) whose activity does no present major issues to population due to their location and therefore do not represent major monitoring targets by the IGEPN.

El Reventador is another remote volcano that was not a main target at the time of its eruption, and Cotopaxi was just finishing an unrest episode that had not turned into an eruption (Molina et al., 2008; Hickey et al., 2015) but concentrated most of IGEPN monitoring effort due to the potential threat that it represents. The authors are wrong about the 2006 July and August crisis at Tungurahua volcano as the warning was issued respectivelly 24 min and 8 hours before the paroxysmal phases (with pyroclastic flows) and evacuation was performed by the civil authorities (Patricio Ramon, 2011, Master thesis; Mothes et al., 2015). In both cases the population was well aware of the threat thanks to the continuous communication system in place since 1999 (Stone et al., 2014). As for the 2015 Cotopaxi unrest, since April 2015 until the 14th of August, the IG-EPN emitted 4 special reports. The last special report from the 07th of August indicates clearly that one of the most probable scenarios for the next days/weeks was the onset of phreatic explosions that could occur at any time. Phreatic explosions are by nature unpredictable as shown by recent eruptions (Kato et al., 2015; Montanaro et al., 2016).

3) Wind directions: the authors use a database that accounts almost entirely for ash plume directions in the troposphere (98% below 40 000 feet, 12 km asl) while the 14 august plume reached the stratosphere ($\sim$15 km asl, washington VAAC). According to INAMHI, the limit between the troposphere and the stratosphere is around 13.6 km asl in the Cotopaxi area. Therefore, the conclusion that an E or NNW direction is "one of the most unlikely and less probable wind directions" is not sustained. A proper statistical analysis using the methodology proposed by reviewer 1 should be done to assess wind directions in the stratosphere. In fact NNW and E plume directions have already been observed during large explosive events in Ecuador (i.e. Guagua Pichincha October 1999, Tungurahua July 2013).

4) Hydrothermal origin: the authors presents componentry description only for the first day of the activity while the eruption lasted about 3 months with peaks of activity at the end of August, mid-October, and mid-November. Even though, as exposed by the

reviewer 2, the methodology used won't neceseraly allows the authors to identify a low juvenile content. Purely hydrothermal events are generally extremelly brief and small volume (Montanaro et al., 2016). Larger ones, such as Mount Ontake 2014 (Kato et al., 2015), are almost always associated to magmatic intrusions. Furthermore since end September, glow was observed at Cotopaxi crater, probably associated to very hot gas. The Cotopaxi unrest phase (>4 months) and its eruption (>3 months, VEI 1-2) point toward a magmatic origin of the activity. This needs to be confirmed with a proper analysis of the eruptive material and geophysical/geochemical signals.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 3, 6947, 2015.