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Tephra and debris flow stratigraphy of the post-XII century activity at Cotopaxi volcano, Ecuador: a tool for lahar hazard assessment.

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Cotopaxi, one of the highest and most dangerous volcanoes on Earth, is a perfect, ice-capped cone reaching an elevation of 5897 m. The volcano is located about 60 km south of Quito, capital of the Republic of Ecuador, and is surrounded by several villages and country's rural infrastructures.

During the past centuries volcanic eruptions and concurrent rapid snow/ice melting have resulted in large debris flows (lahars), which caused major devastation to the settlements around the volcano and traveled downstream for hundreds of km from the source. As a result, lahar hazard assessment is critical, as it represents the basis for effective mitigation actions in the fields of both civil protection and land-use planning.

According to the description of the historical chronicles, during the last eruption occurred in 1877 (and presumably during most of previous historical eruptions as well), the spilling out from the crater of pyroclastic flows (scoria flows) was the major cause of extensive and rapid melting of the ice cap and the formation of large scale debris flows.

Assessment of the lahar impact along the main valleys has been addressed in previous works (Mothes et al., 1998, 2004; Pareschi et al., 2004) using numerical models that assume the last eruption (that of 1877) as the maximum expected event. The assumption of 1877 as the most probable maximum scenario derives from the belief that the

release of water during this event was maximized by the effective interaction of pyroclastic flows with the glacier, whose surface is significantly reduced as compared to that of the second half of XIX century (Cáceres, 2005; IRD, 2004; Jordan, 1983).

We have conducted a detailed mapping of the lahar deposits of Cotopaxi over the period 1150 to present, aimed at assessing the relative scale of different debris flow events based on thickness, maximum block size and extension of the related deposits. Precise and unequivocal identification and chronostratigraphic attribution of different lahars was made, within a radius of 17 km from the volcano, by identifying and tracing fallout beds interlayered with the lahar units. In a similar way, we also assessed the temporal relationships between pyroclastic flows and lahars. Tephra fallout architecture was reconstructed examining more than 400 stratigraphic sites.

The study of the lahar deposits indicates that over the time interval under consideration, the volcano produced debris flows of widely variable scale, from moderate to large to very large. Within this scale, the 1877 event ranks as a moderate lahar, contrasting with other large (AD 1768, the largest for which eyewitnesses descriptions are available) or very large events (XII - XVI century).