

## Identification of a major blast layer resolves debates on the source of avalanche breccias at Imbabura-Cubilche volcanoes, Ecuador

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Imbabura and Cubilche are two volcanoes located near Ibarra, the capital city of the Imbabura province in northern Ecuador. Both edifices suffered flank failure in late Pleistocene times, and widespread Debris Avalanche (DA) breccias are exposed in the area from Iluman to Chaltura, and further east and north in areas of Ibarra and Yaguarcocha Lake. However, the stratigraphy, distribution and source of these undated DA deposits are debated in the literature (see references below). In this work we identified a conspicuous and distinctive volcanic blast deposit resting on top of, or interbedded with these DA breccias, which fix the above issues. The 0.5-to-4 m-thick blast deposit shows a typical 10-25 cm-thick, loose, fines-poor, pumice-rich sub-unit overlain by a ~0.4-4 m-thick massive brownish ashy sub-unit (locally indurated as a “Cangahua” hard ground). The pumice-rich key layer is normally graded, and maximum clast size in it is poorly correlated to distance from source. At a distal site, the brownish ashy sub-unit is overlain by a thin horizon of volcanic debris, implying the blast flow moved faster than the avalanche, a situation reported at other blast-forming eruptions worldwide. At other sites in Ibarra and Chaltura areas, the DA breccias occur as two sub-units separated by a charcoal-bearing blast sub-layer, which was locally mistaken for a paleosoil in previous studies. Yet, new exposures show that these sub-units belong to a single DA event. From observations at 80 sites we infer that prior to local erosion this distinctive directed blast deposit covered all DA deposits now exposed from Iluman and Chaltura to Ibarra and Yaguarcocha Lake areas, and we found no evidence of Cubilche DA deposits there. Accordingly, the ~8 km<sup>3</sup> DA breccias that covered about 200 km<sup>2</sup> before erosion clearly belong to a single collapse event of the NW side of Imbabura volcano. The characteristics of the overlying >0.2 km<sup>3</sup> low aspect-ratio blast layer point to a major, hot and highly mobile surge flow. Silicic juvenile clasts in the DA breccias support crypto-doming as a triggering process for flank failure, though we found ample evidence of recent tectonic compression in the area with folding and uplifted terrains, which may also have played a role in promoting the collapse event. Beyond grain size and radiocarbon results, we will present maps of the DA and blast deposits that allow us delineating the corresponding avalanche caldera boundary at Imbabura volcano. Our findings resolve debates regarding the distribution and source of the DA deposits in the area (Roverato et al., 2018, Andrade et al., 2019) and yield new constraints on the neo-tectonic regime in the Imbabura-Cubilche region. As of today, the blast layer identified in this work is likely the largest ever documented in all South America.

Andrade et al. (JVGR, 2019: in press),  
Le Pennec et al. (JVGR, 2011: 206:121-135),  
Roverato et al. (JVGR, 2018: 360, 22-35),  
Ruiz (Tesis de Ingeniero, 2003, EPN Quito).