

## The Cubilche Volcanic Complex, Imbabura province, Ecuador: a first investigation of its evolution and petrology

W. F. Navarrete<sup>1</sup>, J. L. Le Pennec<sup>2, 3</sup>, S. P. Solano<sup>1</sup>, A. G. Ruiz<sup>1</sup>

<sup>1</sup>Facultad de Geología, Minas, Petróleos y Ambiental, Carrera de Ingeniería en Geología, Universidad Central del Ecuador, casilla 872 A, Quito, Ecuador (ciencia\_wilman@hotmail.com)

<sup>2</sup>Laboratoire Magmas et Volcans, Université Clermont Auvergne, CNRS, IRD, Campus Universitaire des Cézéaux, Aubière, France

<sup>3</sup>IRD, Alemania y Guayanas, Quito, Ecuador

The Cubilche Volcanic Complex (CVC, Imbabura Province, Ecuador), gathers three morphologically well-preserved centres, namely Cubilche (CUB, 3836 m), Panga Ladera (PLD, 3420 m) and Cunrru Dome Complex (CDC, 3300 m). To appraise potential hazards at the CVC, we conducted a volcanological study that includes geomorphologic, litho-stratigraphic, petro-geochemical analyses, and eruption size estimations. We also obtained the first <sup>14</sup>C age determinations that helped us reconstructing the evolution of the CVC and consider any potential reactivation.

The morphology of the CDC shows an eastward-opened scar, which was formed during a dome collapse event accompanied by a directed explosion. The reconstructed debris avalanche deposit (DAD) is of small volume (30 million m<sup>3</sup>) while the directed explosion deposit is recognized over an area of 4 km<sup>2</sup>. The higher PLD edifice is similarly breached to the N and the related DAD (bulk volume of 0.2-0.3 km<sup>3</sup>) is exposed to the NE of the CVC. The activity of a post-collapse PLD stratovolcano ended with emplacement of fines-poor surge flows and formation of a 650 m-wide crater. The old CUB edifice consists of andesitic lavas erupted from the summit crater and from adventive vents still preserved on the lower SW and E flanks of CUB. These lavas are andesites with SiO<sub>2</sub> in the range of 58.4 – 61.0 wt%. The old CUB edifice was partly destroyed by a flank collapse event associated with an explosive eruption that comprised a mobile surge-like pyroclastic density current (PDC) and a significant tephra fall (pumice clasts with 66.0 wt% SiO<sub>2</sub>). The volume of the DAD, which is now concealed beneath younger products, is estimated at about 1.2 km<sup>3</sup>, while that of the pumice fall deposit is at least 30 million m<sup>3</sup>. The PDC deposit is dated at ca 44 ka cal BP. The younger CUB edifice grew rapidly (in about 15 ka) inside the avalanche caldera and comprised several episodes: 1) emplacement of andesitic lavas (58.7 – 59.4 wt% SiO<sub>2</sub>) accompanied by some strombolian activity. 2) Formation of El Abra andesitic dome (58.4 wt% SiO<sub>2</sub>) with generation of block-and-ash flows. 3) Dome destruction during a significant explosive eruption that fed scoria flows, whose deposits dated at ca 32 ka cal BP, are about 40 million m<sup>3</sup> in volume. 4) Another significant explosive eruption occurred at ca 28-29 ka cal BP and left a distinctive pumice fall deposit (volume > 15 million m<sup>3</sup>) in the NE area of the CVC. Finally, some strombolian and phreatomagmatic eruptions carved the young CUB crater, which is now occupied by the small-sized Cubilche Lake.

The CVC can be viewed as a satellite system of the large Imbabura Volcanic Complex (IVC), as our petro-geochemical data point to a common magmatic reservoirs, and the structural evolution of both complexes was seemingly controlled by similar tectonic regimes. As IVC witnessed Holocene activity, we do not fully discard the possibility of a reactivation at CVC. In addition, flank instability and debris flows can be hazardous at CVC and IVC, as evidenced by historical examples.