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Flank Deformation Recorded during Cotopaxi′s Awakening in 2015

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Cotopaxi, a large glacier-topped stratocone in the Ecuadorian Andes begin to display anomalous seismic activity in April, 2015 when the IGEPN′s 15 station seismic network registered an increase in long period seismic events which were located 3-12 km below the crater. Several weeks later a distinct inflationary pattern was observed at the VC1 tilt station, 6 km NE of the crater, where we recorded a steady ascent of 150 urads (daily rate 3.2 urads) through 01 June.

The tilt rate tended to slow and displayed a start & stop tilt pattern through 01 August, when a strong positive trend again resumed. Subsequently, a strong positive tilt pattern was predominante and briefly stalled after the occurrence of 5 small explosions/strong emissions on 14 August, 2015. About September 1st and prior to the onset of a high-energy VT seismic swarm, a rapid onset of strong positive tilt is observed. Subsequently, even though 30-100 VT events were registered daily, the tilt pattern leveled off in November to December, presumably because the events were with magnitudes <1 and that the magma supply was waning?

Five other tilt stations on the volcano are much less sensitive than the VC1 station and this probably reflects the ideal coupling of the VC1 tiltmeter to a thick lava flow, which descends from the summit.

The seven station GPS network displayed a strong displacement to the NW-SW for the stations on the W-SW flanks and had accumulative horizontal changes of 1 cm with a maximum vertical displacement of 1 cm at stations on the S and E. The trends of stations on the NE flank, with their movement purely to the north and east are difficult to interpret, but may be related to a preferential movement upon an old avalanche scar surface and water lubrication.

While the changes detected by GPS are small, they did increase through time and finally, like the tilt, leveled off in November, 2015. We believe that these pattern are the result of small batches of magma ascending up the conduit and provoking slope changes, however small, as recorded by these two methods. InSAR imagery, while not definitive, did not show coherent changes, implying that the volume is small. Ash accumulation from the mid August explosions and subsequent emissions have not surpassed 1 Mm3 (VEI =1) (B. Bernard, Pers. Comm, 2015).

We believe that Cotopaxi has responded to small inputs of magma that rose to shallow levels in the conduit and some of it was erupted, while some doubtless remains in the conduit as a degassed plug that is forming microlites, based on the content of the latest ashes emitted in December and that were petrographically studied.

Since both tiltmeter and GPS responses have coherency with the onset of displacements in April, 2015, we believe that these two methodologies will be informative for when a larger batch of magma enters into Cotopaxi′s edifice. InSAR will also compliment and provide valuable data to guide us in the progress of future intrusions.