Three-dimensional P-wave velocity structure of Tungurahua Volcano, Ecuador

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Abstract

Tungurahua Volcano in the Ecuadorian Andes is a large andesitic stratovolcano (5023 m) that has been erupting mildly since 1999. We studied the three-dimensional (3-D) P-wave velocity (Vp) structure beneath the volcano down to 5 km below the summit. We inverted 1708 P-wave first-arrival times from 263 volcano-tectonic (VT) earthquakes recorded by 5 to 10 short-period vertical seismic stations on the volcano from August 1999 to May 2003. A tomographic inversion method was used to image the velocity structure, in which first-arrival times were calculated with a finite-difference method. The Root Mean Square of the arrival time residuals (RMS) was reduced by 43% after running 10 iterations from the initial RMS of 0.15 s. The relocated hypocenters in our model are tightly clustered along a vertical structure at depths between sea level and the summit crater. A high-velocity zone exists above the central base of the volcano under the vertically aligned hypocenters, and may be interpreted as the source zone for recharge of the shallow magmatic system. High-velocity zones are also identified under the lower northeastern and southern flanks of the edifice. The southern high-velocity anomaly lies close to the surface and is connected to the high-velocity zone in the central base of the volcano, a feature suggesting an old lateral dike system. Except for these high-velocity zones in the central, northern, and southern flanks, the volcanic edifice is composed of low-velocity materials down to a depth of 2 km above sea level. These low-velocity zones correlate with young unconsolidated deposits, and older highly fractured and/or altered volcanic materials.

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