

Volcanism and associated hazards: The Andean perspective

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Cordillera de Los Andes – the tectonic backbone of South America - is the product of subduction of the Nazca Plate and Antarctica Plates beneath the South America Plate over geologic time. Subduction processes not only have built one of Earth's highest mountain ranges, but also Earth's longest continental-margin volcanic arc. The Andean volcanic arc is not continuous, however, but instead it consists of three distinct segments: 1) *Northern Volcanic Zone* (NVZ, Colombia-Ecuador); 2) *Central Volcanic Zone* (CVZ, southern Perú-northern Chile); and 3) *Southern Volcanic Zone* (SVZ, central and southern Chile). These three zones are separated by volcanically inactive gaps hundreds of kilometers in length. The reason for the segmentation of the Andean volcanic arc is not well understood; the prevailing hypothesis is that the gaps coincide with regions where the dips of the subducting plates are too shallow to favor generation of magma by partial melting in hot mantle that sustains volcanism.

The Andes hosts more volcanoes (204) that have been active during the Holocene (i.e., past 10,000 years) than any volcanic region in the world*. Moreover, Chile (plus adjacent Andean Argentina and Bolivia) ranks fifth (after Indonesia, Japan, U.S.A., and Russia) in having the most volcanoes (36) that have erupted one or more times in recorded history. During the past two centuries, Chile has produced seven explosive eruptions characterized by a "Volcanic Explosivity Index" (VEI) of 4 or higher, the same number as for Japan, which – because of its much larger population and higher population density – suffered greater eruption-related impacts. Many of the Andean volcanoes are huge, steep, and often glacier-capped edifices. They are capable of producing devastating lahars, the largest of which have travelled >100 km to reach the Pacific Ocean (e.g., in 1877 at Volcán Cotopaxi, Ecuador).

The Andean region's most powerful historical explosive eruption was that of Huaynaputina, Perú, on 19 February 1600 - the only Andes eruption assigned a VEI of 6. Fortunately, the population in the region at that time was relatively small; thus, the adverse impacts of that eruption, while severe, were not catastrophic. Today, the recurrence of a similar-size eruption would cause many more deaths and cause enormous socio-economic loss. The 1932 eruption of Quizapu (Cerro Azul), Chile, which ejected about 9.5 km³ of material, was the largest eruption of any Andean volcano in the 20th century. The 13 November 1985 eruption of glacier-topped Nevado del Ruiz (Colombia) - though much, much smaller in size (only ~0.02 km³ in volume) -

resulted in the second worst volcanic disaster in the world in the 20th century. Nearly 25,000 people perished from deadly lahars that swept down valleys draining the volcano. The disastrous outcome of this small but lethal eruption happened largely because of: 1) ineffective communications among scientists, civil authorities, and the populations at risk; and 2) emergency-management officials failed to act in a timely fashion, despite having advance, though imperfect warnings given by scientists.

The 1985 Ruiz tragedy was a sobering lesson for the global volcanologic community, prompting it to strive to be better prepared to respond to next volcanic crisis, wherever it may strike. In particular, volcanologists recognized the critical need for an improved strategy of disseminating hazards information and of conveying an appropriate sense of urgency to hesitant government officials. Moreover, the 1985 Ruiz eruption, together with subsequent hazardous eruptions in Chile, Colombia, Ecuador, and Peru has notably accelerated geologic mapping, volcano-hazards assessments, and volcano-monitoring studies of other Andean volcanoes. During recent decades, much has been accomplished in reducing volcano risk in the Andean region. But much remains to be done.

* The following websites provide general information about the Andean volcanic region:

<http://www.volcano.si.edu>; <http://mineralsciences.si.edu/tdpmap>;

<http://volcanoes.usgs.gov>