STRATIGRAPHY AND QUATERNARY ERUPTIVE HISTORY OF THE RUIZ-TOLIMA VOLCANIC MASSIF (COLOMBIA). IMPLICATIONS FOR ASSESSEMENT OF VOLCANIC HAZARDS.

THOURET J-C (1,2), MURCIA, A. (3), SALINAS, R. (3), PARRA, E.(3), CEPEDA, H.(3) and CANTAGREL J-M. (2).

(1) Laboratoire de la Montagne Alpine, URA344-CNRS, Université J. Fourier, 17 rue M. Gignoux, 38031 Grenoble Cedex, F.
(2) Centre de Recherches Volcanologiques, OPG Clermont-Ferrand, 5 rue Kessler, 63000 Clermont-Ferrand, F.
(3) INGEOMINAS, Instituto Nacional de Investigaciones Geológico-Mineras, Regionales Ibagué, Medellin, Popayan, Colombia.

Résumé

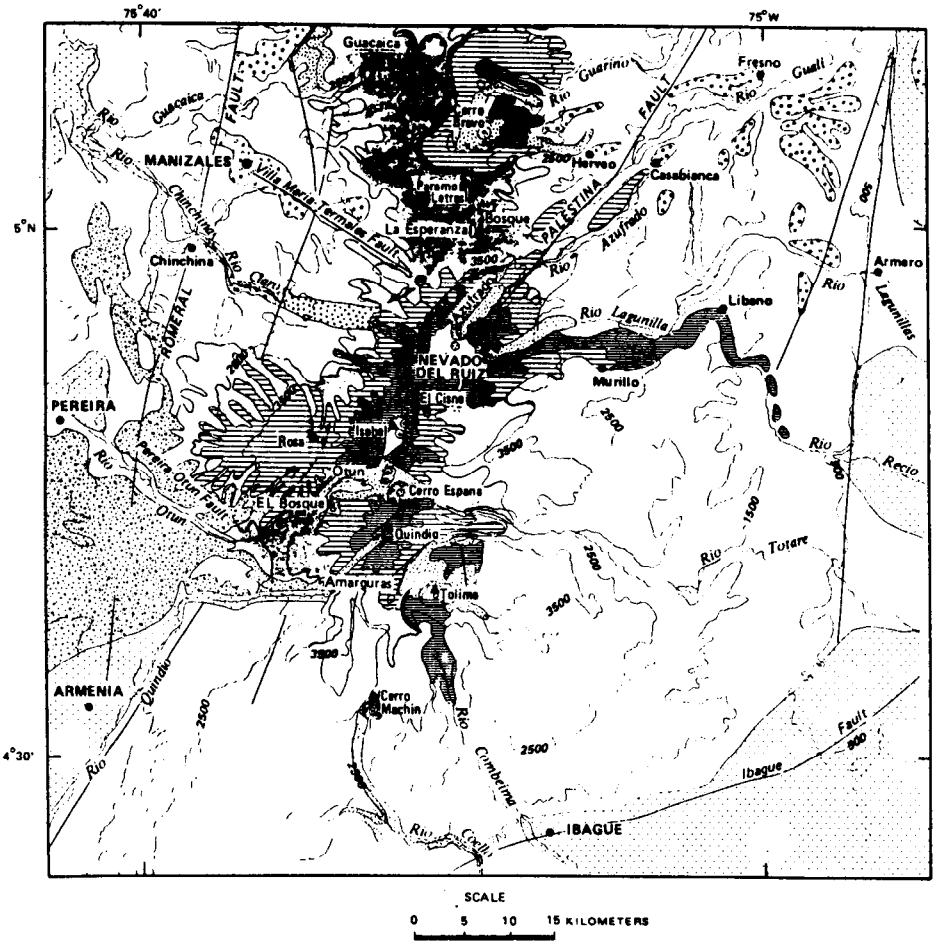
L'histoire éruptive du Massif du Ruiz-Tolima (Cordillère Centrale) depuis 2 Ma environ inclut des périodes alternées d'édification et de destruction de 3 générations d'édifices durant 3 périodes éruptives principales appelées "*ancestrale*" (1.8 - 1 Ma), "*ancienne*" (0.8 - 0.2 ma) et "*moderne*" (< 0.2 Ma). L'activité du massif du Ruiz-Tolima est devenue surtout explosive depuis 50000 ans BP. et 10 à 12 épisodes éruptifs sont survenus depuis 12000 ans BP. Deux cartes de risques détaillées (Ruiz, Tolima) et une carte générale concernent l'ensemble du massif, i.e. 3000 km2 et 500000 personnes en situation de risque volcanique.

Mots-clés : *Colombie, Ruiz-Tolima, volcanisme, Quaternaire, histoire éruptive, risques naturels,*

The Ruiz-Tolima massif (Central Cordillera, 1200 km2 and 2000 - 5400 m in elevation) has a ca. 2 Ma - long eruptive record that includes alternate construction and destruction of three generations of edifices during three main eruptive periods, termed "*ancestral* ", "*older* ", and "*present* " *Ruiz-Tolima* . This andesitic-dacitic range comprises seven major volcanoes (3 being still active) that have been built on the pre-Tertiary metamorphic and plutonic basement of the Central Cordillera. They are located on a complex intersection of four groups of faults, the most significant being the N20°E Palestina fault and the N50°W normal faults (e.g. Villamaria-Termales), and they partly cover basaltic andesite lava flows and dacitic pyroclastic-flow deposits of Pliocene age (4.3 - 2.5 Ma).

"Ancestral" Ruiz-Tolima massif was a group of very large stratovolcanoes built of two eruptive stages of andesitic and basaltic andesite lava flows starting about 1.8 Ma. ago and ending 1.0 Ma. Partial collapses and formation of 5 - 10km wide collapse calderas are thought to have occured between 1.0 and 0.8 Ma. ago (e.g. Letras caldera).

"Older" Ruiz-Tolima massif was a range of large composite stratovolcanoes aligned on the Palestina fault and constructed by lava flows in three stages starting about 0.8 Ma. ago and ending about 0.2 Ma. ago (e.g. Older Ruiz, Tolima, Quindio, Santa Isabel). Voluminous welded and nonwelded HAR pyroclastic-flow deposits, that partly filled pre-existing valleys (Rio Claro, Recio, Combeima), record the formation of explosive summit calderas between 0.2 and 0.15 Ma. ago (Ruiz, Tolima), and perhaps ca. 0.05 Ma. ago.



"Present" Ruiz-Tolima massif is formed by a cluster of composite cumulo-volcanoes made of dacite lava domes and domes that probably filled the summit calderas of Older Ruiz-Tolima. The Ruiz-Tolima activity has become explosive since 50,000 y B.P. on Nevado del Tolima and Nevado del Ruiz (pumice and lithic pyroclastic flows, scoria flows) and on pelean Cerro Bravo and Cerro Machín (block-and-ash pyroclastic flows, phreato-magmatic products and a voluminous HAR pumice-flow tuff). However, this recent activity also includes lava dome and dome growth, parasitic dome and crater activity (around Ruiz), as well as Holocene small-volume block-lava flows around Ruiz and Cerro Espana. 10 to 12 eruptive stages occured during the last 12,000 years, accompagned by rock-slide debris-avalanches, pyroclastic flows, surges, and their subsequente interactions with ice caps, as well as by glacial erosion and mass-wasting. Diverse processes within these stages have led to a partial destruction of the summit domes at Ruiz, Tolima, Cerro Bravo and Cerro Machín.

According to the interpretation of the stratigraphic record of pre-historical eruptions, most of the recent magmatic events were small or episodic, except for those ca. 3600, 3300-3100 y.B.P. Tolima, Cerro Machín and Hedionda eruptive stages, and for the 16th century's Azufrado eruptive stage. The last pre-historical plinian and pyroclastic-flow producing eruptions took place mostly at cerro Machín, Cerro Bravo, Tolima, and Ruiz (ca. 1200-1000, 800-700 and 500 Y.B.P.). Nevado del Ruiz erupted in 1595 AD and in 1985; minor phreatic explosions occured at Ruiz and Tolima during the 19th century. Nevertheless, rockslide debris-avalanches and catastrophic debris flows were triggered in almost all the eruptions owing to slope failures related to specific, active tectonic features and/or to significant interactions between pyroclastic debris and the ice cap. Evidence for upstream retreat of avalanche scarps during multiple eruptions reinforce the case that large slope failures can occur repeatedly at a large-volume volcano like Ruiz or Quindio without reconstruction of the edifice.

From the study of the 2 Ma - long eruptive period, we may conclude:

- Upper Pliocene and Lower-Middle Quaternary eruptions have produced much more voluminous lava flows than during the rest of the Pleistocene;
-although the explosive activity has been renewed since 50,000 years ago, the pyro-clastic flow deposits were much less voluminous than during the upper Pliocene and the lower Quaternary;
- recent explosive activity has migrated towards the intersections of the Palestina strikr-slip fault and the N50°W normal faults, first around Quindio and Tolima, secondly in the Cerro Espana area, and most recently close to Cerro Bravo and Ruiz.

In the light of the past behaviour and the ongoing Arenas eruptive stage at Ruiz (1984 -1990), the most probable hazard still is a lahar-triggering eruption, since the Ruiz and Tolima volcanoes are active and ice-clad. However, the recent petrologic evolution (Holocene dacitic magma and products of magma mixing erupted at Cerro Bravo, Tolima and Ruiz) cannot preclude a large-volume eruption, such as the middle Holocene ignimbrite-producing eruption at Cerro Machín.

Eventually, we present 2 detailled hazard-zone maps at Ruiz (1986) and at Tolima (1989), as well as a general hazard-zone map for the entire massif and surrounding piedmonts (approximately 3000km^2). Consequently, we find 500.000 people at risk (100.000 being at high risk), mostly in the Combeima, Chinchina, Coello-Toche, and Guali valleys and alluvial fans.

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