TEPHROCHRONOLOGY OF THE LAST 5000 YEARS AT CAYAMBE VOLCANO (ECUADOR)

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INTRODUCTION

In their work about the Holocene tephrostratigraphy of volcanoes of Ecuador, Hall and Mothes (1994) succintly presented the recent activity of Cayambe volcano. Since 1995, this volcano has been studied by the Geophysical Institute of the National Polytechnical School of Quito and ORSTOM (French Scientific Research Institute for the Development in Cooperation). To date, a detailed tephrochronology of the last 5000 years of Cayambe's activity and a preliminary geochemical study showing unusual chemical characteristics of its rocks are available and presented here.

CAYAMBE VOLCANO: GENERAL STRUCTURE

Cayambe volcano is constructed on the northern Cordillera Real of Ecuador, which is composed by immense glacial capped stratocones sitting astride a basement which pertains to the easternmost metamorphic chain of the ecuadorian Andes (Fig. 1). The central part of this metamorphic belt mainly consists of triassic semi-pelitic schists and paragneises of continental origin (Loja Division; Litherland et al., 1994). A N35°E and N125°E fault system probably controls the location of the volcano, the La Sofia - Rio Chingual fault being the most important (Soulas et al, 1990; Tibaldi and Ferrari, 1992; Ego et al, 1995) which ends in the NE quadront of the volcano.

Cayambe is a large composite volcano, which has a rectangular base at about 2800 m elevation. Its summit reaches 5790 m and is covered by a huge glacial cap, more than 100 m-thick. Glaciers reach down to 4200 m on the eastern flank and only to 4600 m on the western side. As a whole, the volcano is formed by (Fig. 2) : 1/ A western mostly lavic edifice, the Old Cayambe, which shows strong evidences of glacial erosion. Barberi et al. (1988) report an age of 0.25 ± 0.05 Ma for a dacite sample from this edifice; 2/ The Nevado Cayambe, less voluminous, which was built over the remnants of the Old Cayambe probably after a caldera collapse event. Nevado Cayambe consists of basal lava flows topped by an active summit dome complex which is the source of several recent pyroclastic flows; 3/ a small eastern edifice, called "Cono de La Virgen" from which several thick lavas flowed toward the eastern slopes of the Cordillera (Planada de la Virgen lava flows).

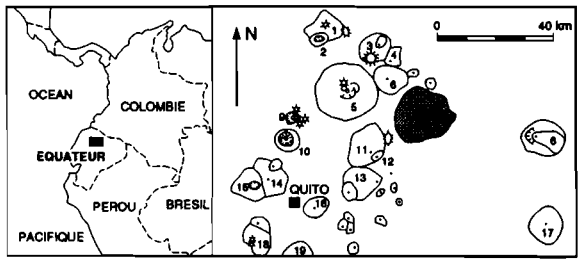
UPPER HOLOCENE PYROCLASTIC ACTIVITY

On the NE flank of Nevado Cayambe, four pyroclastics flow deposits are observed. The older three (PF1 to PF3, Fig. 2) are large dome collapse block and ash flow deposits, whereas the youngest (PF4) is represented by a minor sequence of surges. Within these deposits, dacitic blocks are usually dense, but a few pumitic ones are also encountered. Mineralogical heterogeneity and banding show evidence of magma mixing in the juvenile blocks of three deposits (PF2, PF3 and PF4). The oldest flow deposit (PF1) is massive, 20-30 m-thick, and originated in a dome collapse near the eastern summit (5487 m). PF2, a 100 m-thick multi-layered flow deposit with 15-20 layers has its origin at the small "Tarugo

Fig. 1

Location of Cayambe volcano in Ecuador

1. COTACACHI
2. CUICOCHA
3. IMBABURA
4. CUBILCHE
5. MOJANDA
6. CUSIN
7. **CAYAMBE**
8. REVENTADOR
9. PULULAGUA
10. CASITAGUA
11. PAMBA MARCA
12. IZAMBI
13. PUNTAS
14. RUCU PICHINCHA
15. GUAGUA PICHINCHA
16. ILALO
17. PAN DE AZUCAR
18 ATACAZO
19. PASOCHOA



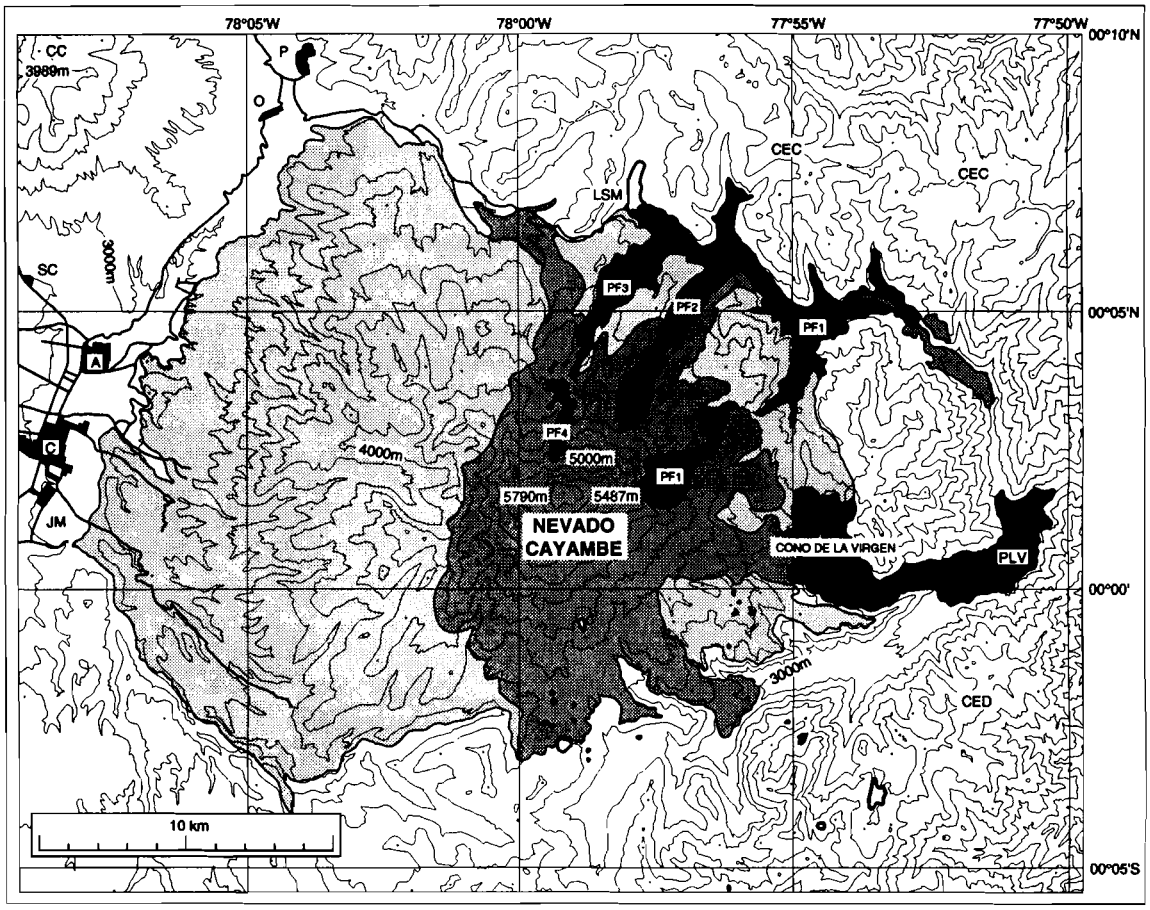


Fig. 2 Cayambe volcano (Ecuador). C= Cayambe town, JM= Juan Montalvo, A= Ayora, SC= Santa Clara, O= Olmedo, P= Pesillo, CC= Cerro Cusin, LSM= Laguna San Marcos, CEC= Cordillera Espinal Chupa, PLV= Planada de la Virgen, CED= Cordillera El Diviso

Cono de la Virgen (active) and Planada de la Virgen lava flows

Nevado Cayambe (active). PF1 to PF4: recent pyroclastic flows

Old Cayambe

Corral" dome (4553 m) , located on the high north slope of the eastern summit. PF3 is massive, also 100 m-thick, and corresponds to the collapse of a dome extruded near the main 5790 m summit ; it dammed the Azuela river, forming San Marcos Lake. Lastly, PF4 corresponds to a sequence of surge deposits which have a total thickness > 10 m. A C14 date obtained from carbonized plants within the soil layer beneath PF4 gives an age of 360 ± 70 y BP.

On the SW flank of Nevado Cayambe, at ≈4000 m elevation, a small glacial valley is presently occupied by an active peatbog. Here, a detailed 4 m-thick section has been studied (Fig. 3), giving us a fairly good record of the last 5.000 years of ashfall and/or pyroclastic flows events of the Nevado Cayambe.

Two eruptive periods which include numerous events, separated by quiescence, form the recent activity of the volcano. Three C14 dates on peat samples from the lower part of the section were obtained. They show a long period of eruptive activity from 3900 to 1800 y BP. A second long period has been observed, up to present time. The results of three additional datings will constrain the duration of this second period which has probably not concluded. As evidence, Ascazubi (1802) in a letter to A. von Humboldt describes an small eruptive event of Cayambe in 1785, i. e. ≈165 y BP, which could be considered the last eruption. At present, mountainers frequently report a strong sulphur smell in the summit area of the Nevado.

GEOCHEMISTRY

55 samples from Old Cayambe, Nevado Cayambe and Cono de La Virgen have been analyzed for major and trace elements. All SiO2 contents range from 59 to 67% (LOI free and total recalculated to 100%). The rocks are medium-K andesites and dacites, except for samples from Cono de La Virgen which are high-K andesites. All the rocks from Nevado Cayambe are depleted in Y and Yb and have high La/Yb and Sr/Y ratios. The origin of these rocks (adakites) is discussed by Monzier et al. (this volume). On the contrary, the few rocks analized from the Old Cayambe are normal calc-alkaline series.

CONCLUSIONS

Nevado Cayambe volcano has been very active during the last 5000 y BP, this activity being mainly characterized by lava dome extrusions, dome collapses and pyroclastic flows. The geochemical characteristics of the resulting products argue for a dominant melting process leading to a large adakitic suite in which crystal fractionation only plays a minor role. Magma mixing is also present, especially in the recent phases of the volcano.

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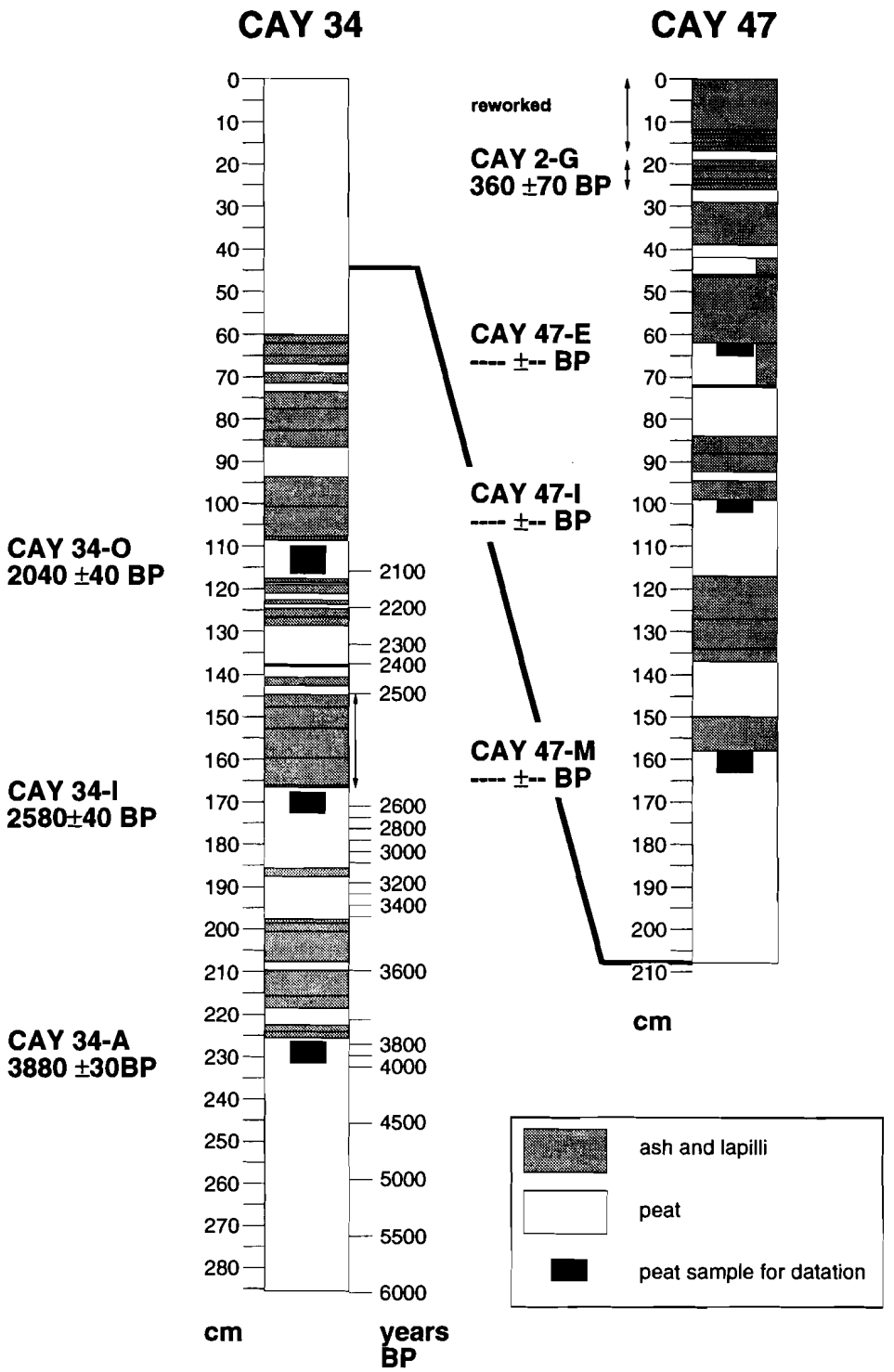

Fig. 3 Nevado Cayambe bog. Cross-section through the ash and lapilli and peat layers; C14 dated samples are shown (results of the last three datations are soon expected). Ages on the right side of the columns are calculated assuming the layers of tephra were deposited instantaneously.