

THE VOLCANO PURACÉ

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ABSTRACT. The volcano Puracé (4,596 meters) in southern Colombia has been active within historical times. Despite its geological importance little has been mentioned of its development in geological literature. Thus far the only published record of scientific observations at its crater were made by W. Reiss in 1868. The studies of the writer during two visits to the volcano, in 1947 and 1949, provide additional and recent data.

Puracé is at present the only active vent of a group of Pliocene volcanoes at the northern edge of the Cauca-Patia batholith in the Cordillera Central of Colombia. The rise of this batholith could be related to the emergence of the Cordillera Oriental Geosyncline to the East. The group of formerly very active volcanoes, of which Puracé forms part, are obviously located on tectonic lines of crustal weakness of this part of the Andes.

The eruptions of Puracé are of explosive character. The ejecta are of andesitic nature. The upper cone is built of andesitic lavas, bombs, lapilli and ashes. The lower part of the volcano is, however, made up of thick flows of dacite. The total height of the volcano is about 2,000 meters above the crystalline basement of the Cordillera Central.

The periodicity of eruptions of Puracé could not be established; however, it still appears very active. The explosive eruptions are of an intermittent character and in recent times were not accompanied by lava flows.

INTRODUCTION

THE volcano Puracé in the Department of Cauca, Colombia, is situated some 30 kilometers S. E. of Popayan (1,741 meters) in the upper Cauca valley at about 2° 20' Lat. N. and 76° 25' Long. W.

The exact altitude of the top of the volcano was given by different authors as varying from 4,900 to 4,700 meters. The writer's observations with aneroid have shown only 4,590 meters above sea level.

The volcano was ascended by the writer first on April 27, 1947, and again an attempt was made on June 11, 1949; this time accompanied by the writer's wife and the French geologist, de Sakowetch. On both occasions the volcano was in a state of near activity. On April 27, 1947, an eruption was witnessed by the writer at 7:00 A.M., some six hours previous to his ascent to the crater. At this time a column of steam and smoke which reached about 1,000 meters above the crater was visible. Lapilli from 5 to 10 millimeters in diameter were projected to a distance of over 10 kilometers from the crater, and ashes covered the streets of Popayan.

On June 11th an earthquake lasting about 30 seconds shook

the region and the village of Puracé at a distance of about 10 kilometers from the volcano. Due to exceedingly bad weather conditions, rain and storm, and the danger of pyroclastic materials, the party had to return from an elevation of approximately 4,000 meters without reaching the upper part of the cone. Before this ascent on May 26th, a violent explosive eruption of Puracé, also preceded by local seismic shock, caused the death of seventeen students of the University of Popayan who were attempting to reach the cone of the volcano. On both occasions there were no flows of lava and the eruptions were accompanied only by outbursts of gases, steam, volcanic bombs and rocks; large rock fragments which fell from considerable height were responsible for the casualties.

HISTORICAL DATA

Although Puracé has existed as a volcano since Pliocene times and evidently was active during historical times, the first mention of Puracé's activity was made by Humboldt in 1801, and later by Boussingault in 1831. Neither of the two has, however, left a written or graphic description of the volcano.

One of the earliest eruptions of Puracé is mentioned by A. Stuebel as having taken place on November 18, 1827. From his travels in later years it appears that Stuebel had not succeeded in reaching the crater despite his persistent efforts.

Wilhelm Reiss (1921), Stuebel's companion, with whom he studied and described many volcanoes of Ecuador and Colombia, was the first scientist to describe Puracé and its crater, following his ascent of November 18, 1868. Reiss refers to a number of violent eruptions of Puracé between December, 1849, and 1852. After these eruptions it appears that the top of the mountain had been considerably lowered. According to Reiss (1921) the inhabitants fled from the neighboring village and the town of Popayan was covered with a blanket of ashes. Many small eruptions which occurred since have not been recorded. Reiss also describes an eruption of October 4, 1869, which was accompanied by an earthquake and large mud-flow. There were no further eruptions recorded until May 25, 1885, when, according to the memory of the inhabitants, a catastrophic explosion of Puracé accompanied by an earthquake killed many people and destroyed many houses in the

region; the exact number of casualties was not recorded. The church of San José and many buildings in Popayan also were destroyed. A strong eruption of October 12, 1925, and a later one of November 5, 1925, are the first recorded activities of Puracé in this century. The observations were made by I. Friedlaender (1927) who also mentions another eruption of September, 1926, which was accompanied by flames and ashes. He observed the eruptions at a distance; his attempts to climb Puracé were, however, unsuccessful.

Subsequent eruptions were not recorded until April, 1946, when, according to the inhabitants of the village of Puracé, as related to the writer, a strong explosive eruption preceded by an earthquake shook the region, damaging the village church. The earthquake was felt also in Popayan.

The later recorded eruptions took place on April 27, 1947, when the writer ascended to the crater (fig. 1). The column

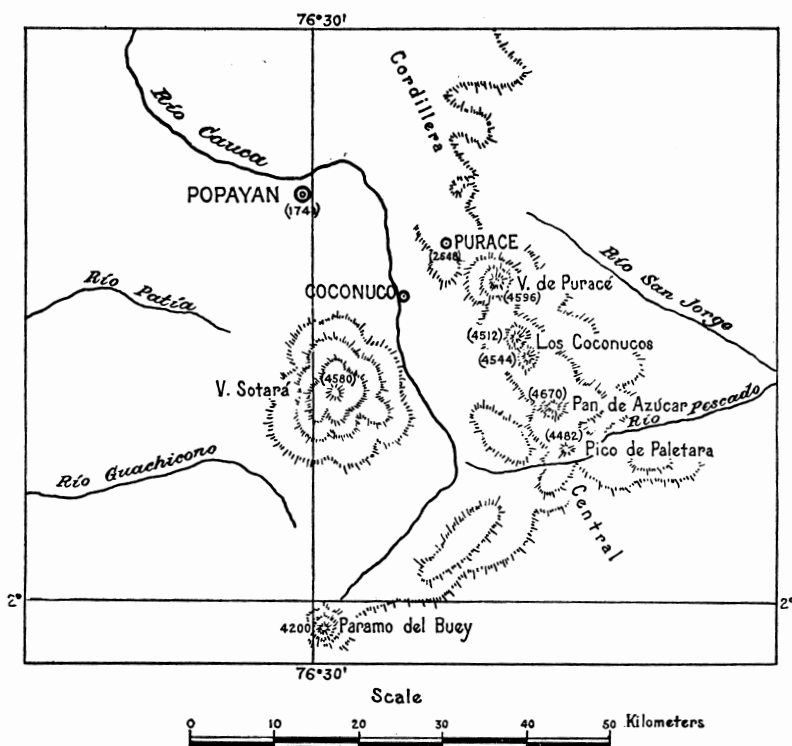


Fig. 1. Index map of Puracé Range, Colombia.

of smoke on this occasion rose to about 1,000 meters. A few days before this, ashes and lapilli fell to a distance of more than 10 miles from the volcano. On May 26, 1949, there occurred an explosion, again with an earthquake and great quantities of ashes and bombs. The earthquake of June 11th which was experienced by the writer and his party was probably also accompanied by an explosive eruption. This, however, could not be observed due to dense clouds that enveloped the mountain.

From the sporadic, available data of the activity of Puracé over more than a century it would appear that the volcano has only slightly diminished its explosive character since the time of its first-recorded eruptions.

The lack of systematic observations, such as should have been carried out considering the nearness of the volcano to villages and towns, make it impossible at present to determine the periodicity of the eruptions as well as the exact evolution of the cone and crater. The writer's observations of April, 1947, as compared to those of Reiss of November, 1868, give interesting material for the study of the development of Puracé during the last eighty years.

REGIONAL PHYSIOGRAPHY

Puracé forms the northern peak of a high volcanic range of the Cordillera Central, known as Sierra de Coconucos; Reiss (1921) also called it the Puracé Range. The volcano lies some 85 kilometers south of Nevado de Huila (5,750 meters), the highest volcanic peak of Colombia, and 25 kilometers northeast of the conspicuous volcanic peak of the recently active Sotaré (4,580 meters). Eighteen kilometers southeast of Puracé lies the symmetrical volcanic cone of Pan de Azucar (4,670 meters). This appears to be quite extinguished. The Puracé Range extends about 25 kilometers to the southeast, the southernmost peak of the range being Pico de Paletara (4,482 meters).

Puracé, therefore, forms the apex of a group of three volcanoes of which it is the only active one at present since Sotaré and Pan de Azucar are latent or dormant. The Puracé Range together with the volcano Sotaré to the west of it border on both sides the uppermost valley of Rio Cauca, the southeastern headwaters of which descend from the range.

The southernmost sources of this great river originate, however, approximately 35 kilometers to the south at the Páramo del Buey, whence also descend the sources of Rio Magdalena, flowing to the east and Rio Patia, flowing to the south. This area of Colombia, where the largest river systems of the country originate, lies on a batholith of younger Tertiary age intruded into the older massive of the Cordillera Central. The volcanic range of Puracé as well as the active and dormant volcanoes of the region apparently represent magmatic outflows related to the rise of this batholith.

Rio San Francisco and Rio Vinagre descending from Puracé, both have deeply cut valleys. The valley of Rio Vinagre, which has its source at the cinder cone of the volcano, shows evidence of extensive mud-flows in its upper course. The waters of Rio Vinagre are highly sulphurous and according to some analyses carry over one percent of sulphuric acid and about one percent of hydrochloric acid. Several hot sulphur springs empty into the river. In its upper course the river bed is cutting thick sulphur layers at the foot of the volcano.

GLACIATIONS

Evidences of past glaciations around the volcano and on its lower flanks above an elevation of 3,500 meters are found in the form of typical U-shaped valleys, hanging valleys, glacier-polished surfaces and what might be remains of moraines. In the valley of Rio San Francisco glacial forms could be observed as low as 2,880 meters. This points to an intense glaciation that must have affected the whole range in Pleistocene times, and during the time that Puracé was most active. This confirms that Puracé is of pre-Pleistocene age.

Humboldt, at the beginning of the last century, as well as Reiss (1921) in 1869, described the range and particularly the peaks of Puracé and Pan de Azucar as being covered by an extensive snow cap. Likewise, within the memory of the old inhabitants of the region, ice and snow were carried by Indians to the town of Popayan for refreshment. Reiss, during his visit to the crater of Puracé, found about 70 meters of perpetual ice and snow on the crater's rim. But only patches of ice were reported at the top of the

mountain by 1934. At the time of the writer's visit to the crater there were found no traces of perpetual snow or ice; and a snow which fell on top of the mountain at this time melted instantly. The temperature at about 3:00 P.M. was 9° centigrade.

The lack of ice and snow on Puracé in recent times is largely due to the general process of deglaciation that is affecting the Andes (Oppenheim, 1948). The possible lowering of the crater due to successive explosions is also a consideration which, in the case of Puracé, should not be overlooked. On the other hand, there is evidence that recent eruptions have contributed to the growth of the volcanic cone.

GEOLOGY OF PURACÉ

Metamorphic crystalline slates are observable in the river valleys below the village of Puracé (2,648 meters) at an elevation of about 2,600 meters. These form the basement upon which is built the volcanic massive of Puracé. The height of the volcano above its foundation is thus about 2,000 meters, and its diameter at the base could be estimated at roughly 10 to 15 kilometers.

Dacite lavas of reddish color appear slightly inclined and in part lying almost horizontally, forming the lower part of the volcano up to an altitude of about 3,800 meters. They form a steep lava wall at the northwestern approach to the volcano. The truncated cone of Puracé above some 3,800 meters is made up of dark andesitic lava-flows interbedded with great amounts of andesitic tuffs, ashes, bombs and large blocks which form the pyroclastic cone of the volcano (fig. 2). Puracé therefore has a composite constitution. The dacitic shield volcano at its base is capped by an andesitic and pyroclastic cone. The andesitic lava-flows and tongues were apparently very viscous and did not flow far from the crater despite the steep flanks of the volcano; the more recent flows were observed above 4,000 meters altitude.

On the northwestern side of the volcano and close to the main crater there appears part of a wall rising a little below the height of the crater rim. This may indicate the former cone of the crater or the wall of a parasitic crater that existed northwest of the present one. A small secondary crater is located

PLATE 1



Fig. 1. Pyroclastic materials on the flanks of Puracé. In the center, cavity made by volcanic bomb (photograph by author).



Fig. 2. Typical volcanic bomb of Puracé (photograph by author).

on the eastern flank of Puracé but could not be properly investigated.

The crater of Puracé, when observed in 1947 had a diameter of about 500 meters. It was totally made up of ashes, tuffs and other pyroclastic materials. The outer flanks have an inclination of about 30° . The inner walls, however, appeared

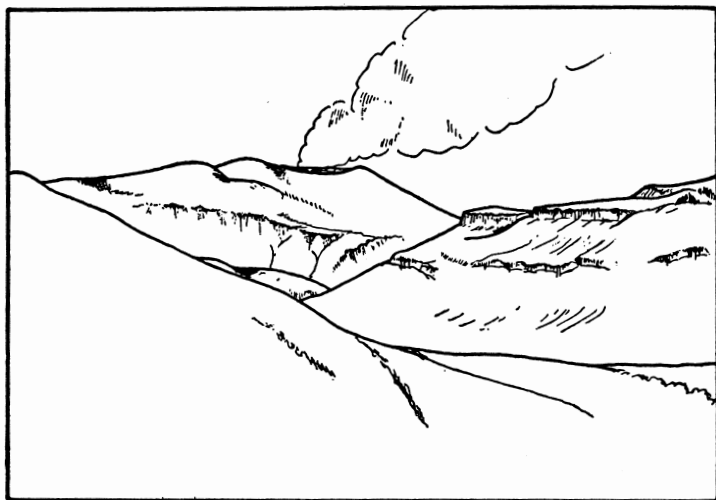


Fig. 2. View of Puracé in eruption in 1947 (from photograph by author).

much steeper and descended some 50 meters from the outer rim of the crater. At that level began the steep walls of the inner crater, issuing a column of steam, smoke and ashes.

Two fumaroles were observed some 150 meters from the rim of the crater on the outer western flank of Puracé. The smaller one, situated a little to the north and somewhat higher, was emitting steam in short periodic intervals simulating a steam engine. The second fumarole, a little lower and more to the south than the first one, showed a deep, wide cavity in the flank of the volcano and appeared surrounded with lava-flows, as well as layers of sulphur. It was emitting steam under less pressure than the first one.

The thick cover of pyroclastic materials forming the cone of Puracé consists predominantly of lapilli, with many large angular blocks of andesite which were torn out of the walls of the conduit of the volcano (plate 1, fig. 1). Some of the observed blocks were about 6 meters wide and 2 meters high. Upon falling,

these bombs formed cavities in the tuff-bed of the cone; some of them 4 to 5 meters wide and 2 meters deep. True lava bombs, although present, were not as frequent as the angular volcanic blocks (plate 1, fig. 2). Some of the bomb cavities appeared to have been made by blocks which were projected to the surface the morning of the ascent or a day or two previous, since the cinder beds were freshly disturbed.

The deeply cut gorge immediately below the second fumarole is the source of Rio Vinagre. Within a mile it opens into a deep cut in the western flank of the mountain, where are displayed effects of large, recent mud-flows.

When visited by the writer the cone was totally free of ice and snow, and the deep rib-like grooves described by Reiss (1921) at its top were absent. There was likewise no visible trace of the small lake on the floor of the crater as described by that author in 1868.

CHARACTER OF ERUPTIONS

The periodicity of the eruptions of Puracé has not as yet been determined. Most of the investigators who have studied it from a close distance during the past century found it in some form of activity.

On many clear mornings the workmen of a sulphur mine near Puracé, at an altitude of 3,600 meters, have reported seeing a tall column of smoke rising above the volcano. The old inhabitants of the region have observed that the Puracé eruptions are particularly frequent during the months of May and June; these are the rainiest months in this part of the country. It seems possible, therefore, that the explosive eruptions are particularly strong during these months because of infiltrations of meteoric waters into the crater.

The cause of the sporadic activity of the volcano in recent times would have to be looked for in the apparently continuous expansion of juvenile gases fed to the crater from some depth. These, however, do not seem to have been accompanied by lava-flows. Judging by the early description of the volcano the character of the explosions does not seem to have changed much in the last century. The fact that great mud-flows have accompanied eruptions in the past and do not occur today is due to the deglaciation which has been followed by the complete melting of the formerly existing snow cap. The eruptions,

however, are still accompanied by local earthquakes and by emissions of considerable masses of pyroclastic materials and bombs projected to great distances. It is also noteworthy that the fumaroles when observed by the writer in 1947 seemed to be as active as when described by Reiss 78 years ago.

All these factors of the past and present activity of Puracé tend to indicate that the volcano has not greatly reduced its explosiveness in the last century and, although it seems to have passed the stages of the magmatic eruptions of its earlier history, it can still be considered as one of the very active volcanoes of the Andes.

The fact that the other volcanic cones of the Puracé Range to the south, as well as the volcano Sotará to the west appear inactive in recent times, would suggest that the tectonic adjustment of this zone of crustal weakness of the Andes is nearing its completion. The activity of Puracé is, therefore, the only remnant of a formerly far greater plutonic activity in the Cordillera Central of Colombia.

REFERENCES

- Friedlaender, I., 1927. *Über einige Vulkane Columbiens: Zeitschr. Vulkanologie*, Band X, I Teil, pp. 167-169.
- Oppenheim, V., 1948. *Deglaciation in Colombia*. In report of International Commission on Snow and Glaciers, Oslo.
- Reiss, W., 1921. *Reisebriefe aus Sudamerika, 1868-1876*. Festschrift zum XX Deutschen Geographentag, Leipzig, pp. 61-68.

BOGOTÁ, COLOMBIA